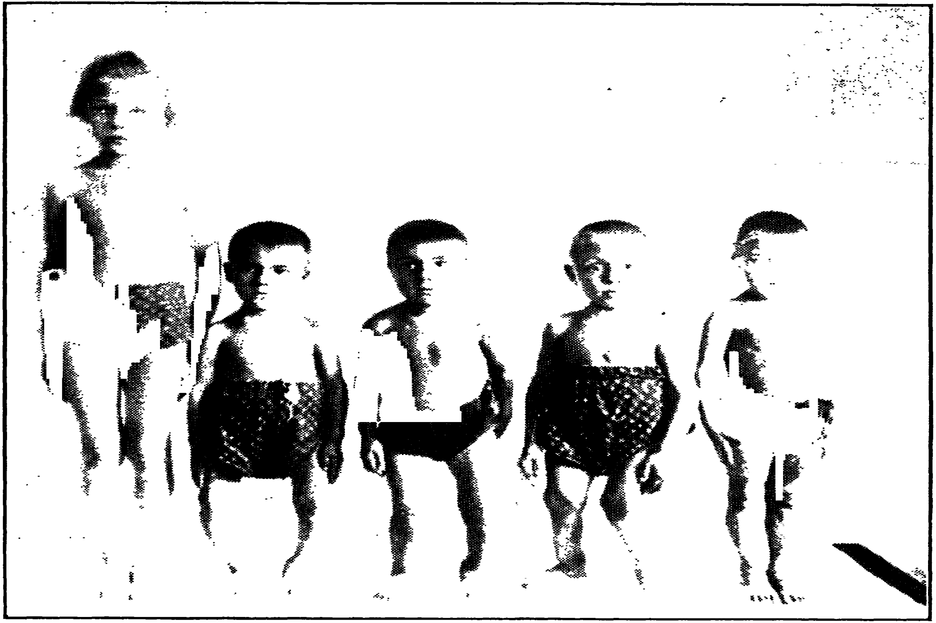
To

My dear little Mother

NANDITA



These children are all the same age. The tallest child received a diet containing the necessary amounts of calcium and vitamin D. The others lacked both.

By courtesy of the United States Department of Agriculture.

What to Eat and Why

By

N. GANGULEE, C.I.E., Ph.D.

With a Foreword by

JULIAN HUXLEY

It is a difficult task, my fellow citizens, to speak to the belly, because it hath no ears.

Cato

INDIAN BRANCH

HUMPHREY MILFORD

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FOREWORD

Our knowledge of nutrition has been entirely transformed during the past thirty years. The discoveries of physiology concerning vitamins and other accessory food-factors have at last made it possible to set up proper standards of nutrition, while at the same time revealing that the diet of a surprisingly large proportion of the population, even in the wealthiest countries, falls far short of those standards. The revolution in our ideas on human health is as important as that effected by the discoveries of last century concerning infectious disease.

Everywhere in the West, efforts are now being made to apply these new facts and ideas in practice; not least by way of education. Professor Gangulee's book is to be warmly welcomed as a sign that the East is not going to allow itself to lag behind the West in this field. The general problem is the same in India as in England, but many details are inevitably different, and it is necessary for any book designed for Indian use to take account of these differences. This Professor Gangulee

has attempted in *What to Eat and Why*, and I hope that his pioneer effort will be deservedly fruitful.

JULIAN S. HUXLEY

CONTENTS

PREFACE

In presenting a textbook on any scientific subject for schools in India, the author is confronted with the task of having to address pupils with an extremely limited working knowledge of elementary science. Nevertheless, the problem has to be faced. The compulsion to brevity and to explanation of scientific matter in popular terms tends either to vague generalizations or to expressions which are not easily understood. I have tried as far as possible to avoid these difficulties and to treat the subject of human nutrition without sacrificing its scientific aspects. With the help of teachers this book may succeed in presenting the knowledge of nutrition to those even with little or no previous experience in science in a manner which may evoke an incentive to pupils to pursue the subject further.

The requirements of diet and its relation to health can be best understood and the significance of the various food constituents fully appreciated only after we have formed some idea about the processes of nutrition in

the body. Once the mechanism of the living body is understood, the way to impress upon the pupils the newer knowledge of nutrition will be comparatively easy. That is why Mahatma Gandhi tells us in his *Guide to Health* that 'every one should regard it as his bounden duty to know some of the fundamental facts concerning his body'. This kind of instruction should indeed be made compulsory in our schools.

London, 1939 N. GANGULEE

What, indeed, is the use of spending public funds on objects such as education, welfare schemes and the like if the people have not the health and vigour of mind and body to take full advantage of them and to enjoy them? . . . For, in truth, the response of the individual to the opportunities of life, whether economic, cultural or political, is inevitably inadequate in the absence of that vigour and ambition and of that joy in life which belongs to the possession of a healthy and balanced mind linked to a healthy body.

His Excellency the Marquess of Linlithgow

Viceroy and Governor-General of India

Chapter I

INTRODUCTORY

The relation of nutrition to health is so vital that the importance of educating boys and girls early in their life in the basic scientific principles underlying that relationship is no longer questioned. Before their habits are formed, pupils should have an adequate understanding of the main factors that ensure health and how the consumption of food regulates and maintains their physical and mental well-being. It is not, as a French savant observed, 'when life is waning that we should learn how to live . . . As soon as the mind develops we must inculcate into habit the means which should be pursued to preserve the greatest of all boons: health . . .' If school children knew more about the body and its functions; if they realized that a considerable injury to health is done through their own ignorance; and if they fortified themselves by knowledge of the role played by food in keeping the body fit—if these results could be achieved through a systematic health education to school

children in India, it would tend to cultivate well-balanced judgements in the choice and use of food. They should be made to realize that nutrition is the most fundamental *single* factor in the health of the individual.

But there is no adequate provision for health education in our school programme; nor is there a proper 'atmosphere' of health in our schools. A negative type of health education cannot influence habits or outlook. In advanced countries health education is defined as 'the sum of all efforts to modify human conduct and attitudes so as to raise the health levels of individuals and of the community'. In this sense, it has not as yet properly begun in India.

The use of preventive medicine and the application of sanitary knowledge to personal and communal life have resulted in 'an extension of the frontiers of life'. The science of nutrition now holds out a promise of the enjoyment of positive health by directing us to adopt a new standard of food requirements. It should be impressed upon pupils that health is something more than merely freedom from disease, and that many symptoms of ill-health may be attributed to a faulty diet. Teaching based upon a positive idea of health

should, therefore, include a general understanding of sound physiological principles, and a wider view of the problem of dietetics.

The first step towards nutritional education in schools must lie in assisting teachers to understand the problem in all its aspects. They should be familiar, not only with exact knowledge of the science of nutrition, but also with the social purpose involved in its application to practical work. The attainment of health and the well-being of pupils must be their chief concern. They themselves should realize and make their pupils understand, that positive health is not merely a boon to them, but it is a responsibility towards the country. Indeed, the teacher has a rare opportunity for arousing a keen interest in health, one of the essential controlling factors of which is proper food.

In India we have no systematic medical inspection and supervision of school children, but evidence is available showing that a surprisingly large number of them are found to be malnourished. Evidence of malnutrition is largely written on the physique of all classes of our population, and defective nutrition is undoubtedly responsible for a general lowering of their working efficiency.

One may even trace the root causes of many psychological abnormalities that characterize large sections of our peoples to dietary deficiencies. But no age group is more seriously affected by undernourishment and malnutrition than that of school children. The symptoms of malnutrition are found among children in all economic levels. Yet no concern is felt about their dietary needs and habits. Our parents at home and superintendents in boarding schools are, as a rule, ignorant of the principles of practical nutrition and also of the actual food values of various Indian food-stuffs. Even among the enlightened communities, the question of dietary adjustments is regarded as a fad.

The chief cause of widespread malnutrition among the great bulk of our population is, of course, poverty. It is also true that agriculture in India is in the grip of such economic circumstances that the industry remains in a primitive state and unrelated to the nutritional requirements of the people. But ignorance, apathy and dietary customs add their contributory factors to faulty nutrition and ill-health.

The most striking defects of average Indian dietaries are: (*a*) *excess* of carbohydrates,

i.e. starchy foods and sugar; (*b*) low protein content; (*c*) inadequate fat, and (*d*) poverty of vitamins and inorganic constituents. These deficiencies may be entirely corrected if in making dietary adjustments we are guided by intelligence as to the nutritive properties of food.

It is often argued that man's instinct for food should be a reliable and sufficient guide. Within definite limits this may be true but we must recognize that instinct is subject to circumstances of life and its environment. Besides, even if we could give free play to the instinct in food selection, our choice would not always conform to what is best for our health. That is why many wrong dietetic habits persist amongst us and a one-sided cultivation of taste leads to false doctrines in regard to food selection.

But the subject of nutrition covers a wide range of social and economic problems. In his task to teach school children how close the relation of proper food is to normal growth and health, the teacher should be assisted by every possible agency. It is only through co-ordinated efforts that his teaching can be made really effective. The co-operation of the

Medical and Public Health Officer with the teacher in making the school a real centre for health education is overdue and should be made possible without delay.

'There is no subject', observes Sir Robert McCarrison, 'more worthy of the consideration of those whose life is spent, or to be spent, in guarding national health. It seems to me that in regard to it we have three obvious duties: the first, to instruct the masses as to what to eat and why to eat it; the second, to apply the results of our science to the production of natural foods in abundance and cheap distribution, rather than to the erection of institutes for the treatment of maladies due to their want; the third and most important, ardently to pursue our investigations and the acquirement of knowledge.'

Another link in a co-ordinated system of health education is the social worker. Through his co-operation, it may be possible to interest the parents in such efforts as the teacher may undertake for the dissemination of nutritional knowledge among his pupils.

As regards methods of instruction, they should be left to the judgement of the teacher. No standardized method can make teaching

lively. What is necessary is a general knowledge of biology and also a capacity for devising simple experiments to demonstrate certain general characteristics of living things. An outline of such demonstrations, together with necessary charts, graphs, and photographs, to assist the teacher should be supplied by the All-India Institute of Public Health and Nutrition Research Laboratories; and it should not be above the wit of Education and Public Health departments to train the teachers of secondary schools in certain recognized methods of detecting malnutrition.

In preparing a book for the purpose of presenting a broad outline of the science of nutrition I have avoided theoretical details, and have stressed those essential principles which underlie the knowledge of nutrition and its relation to health. Nutrition is not a simple science. Knowledge of the chemical composition of our common food-stuffs would appear interesting if presented in relation to the *functions* of essential dietary constituents. In explaining the functions I had to use technical terms for the sake of clarity and the reader may, now and then, find what appears to be repetition. Some of the

scientific expressions require further explanations, and the teacher is expected to supply them more adequately than I have been able to do within the limit of this book. For guidance, a glossary of scientific words used in the text is given in an appendix.

Since nutrition is a fundamental function of the body, it is necessary to become familiar with the various processes of digestion and assimilation from the moment food is introduced into the mouth to the elimination of its waste products. I have therefore devoted a chapter to a brief résumé of the changes in the essential food substances which take place in the digestive system. It is of the utmost importance that the pupil should have an adequate understanding of the general organization of the living body and of its functions in relation to the process of nutrition. It is hoped that the teacher may be provided with technical diagrams and pictorial representations of human physiology in order to enable him to give a general idea of the processes involved in the transformation of food in the body.

I have devoted a chapter to a general discussion upon common food-stuffs available in India. It is to be hoped that the teacher,

with the help of appropriate books of reference, will be able to supplement this with facts pertaining to cereals, vegetables, fruits, and milk products, etc., available in his locality.

It is not easy to form a clear idea about the nutritive constituents in food-stuffs without demonstrations. I hope it may be possible for the teacher to conduct simple experiments demonstrating certain established facts related to nutrition. I have therefore suggested a few experiments for his guidance, and it is my firm conviction that they will serve to excite curiosity and to stimulate interest in food-stuffs.

This book is written primarily to meet the needs of the teachers and pupils of India and the social worker. While the various complexities of the problem of nutrition in India cannot be solved by piecemeal efforts, I believe much progress can be achieved, even at the present stage of chaos and confusion in our social and economic life, by spreading the knowledge of the fundamentals of nutrition. We must do all we can, not only to make the young generation 'nutrition conscious' but to remove what an English writer describes as the 'ignorance of

the educated'. If this book serves to draw more than an oblique attention from the teacher and social worker of my country, I shall feel amply rewarded for my efforts.

Chapter II

THE LIVING BODY

The simple terms, life and living, are difficult to define. We do not yet understand the meaning of life; but, as science reveals with increasing rapidity the processes of living things or organisms, we gain more and more control over its mode of expression. Knowledge of these processes is helpful in improving our health and well-being; and without health we cannot realize the joy and dignity of being alive.

Man is both a mind and a body—closely related in their development and action during the course of his life. The physical organism through which life expresses itself is the body which has two main functions to perform:

1. To grow, maintain itself, and adapt itself to its surroundings by the conversion of food, water, and air into tissues and energy.
2. To reproduce other individuals of its species, after it has become fully grown.

We are here concerned only with the first. A very important aspect of this which has only recently begun to receive the attention it

merits is nutrition. To understand fully the meaning and role of nutrition it is necessary to know something about the functions of the living body as a whole, i.e. its physiology, which, in turn, involves a considerable knowledge of its structure or anatomy.

Man is one of the million or so species of animals which, with the plant kingdom, form the sum of living things on the earth. These animals vary in size from minute forms, like the malaria parasite, which can be studied only with the highest powers of the microscope, to enormous whales which measure over a hundred feet in length and weigh perhaps a hundred and fifty tons. They vary greatly in shape and, what is more important, in complexity. Different species of animals frequently have to compete with each other for important necessities such as food and the chances of winning this competition depend upon whether a species can easily become adapted to changes in its surroundings, or what we call its environment. Some animals are found to be able to live normally in a changing environment better than others. It is important to realize that although man has the most complex and finely adjusted brain known, the main pro-

cesses by which he lives are precisely the same as those involved in the life of the simplest type of organisms, for example, amœba. In other words, all living things have many features in common.

The living substance of the body is a complex mixture of substances called *protoplasm* which in most tissues consist of a slimy jelly. Amœba consists merely of a speck of protoplasm, just visible to the naked eye, containing a portion of protoplasm, different from the rest, termed the *nucleus* which seems to control the whole organism in some way not understood. Yet although so simple, amœba performs all the essential functions of life; it feeds, breathes, excretes, moves, is sensitive and reacts to external stimuli of various kinds and, finally, reproduces. In the middle of the nineteenth century, two physiologists demonstrated that this same material, protoplasm, is enclosed in the cells of higher animals as well as plants. 'Cells' was the term unfortunately given in the seventeenth century to the minute compartments of plants, observed when microscopes were first applied to the study of plants, before it was realized that the protoplasm and not its covering makes the cell. These cells

are the structural units of living matter and of all vital functions and the life of each is controlled by a nucleus.

In man, millions of millions of these cells of varying shape and size build up the tissues of the body much as bricks build up the walls of a house. The cells of a particular tissue are adapted to perform one or two special functions of the body—almost to the exclusion of all others—that is, our body-cells are *specialized*. For example, certain cells of the retina of the eye are adapted to react to light, cells of the nerves to convey messages to and from the brain and spinal cord, and of the muscles to contract. Unlike the unit of protoplasm in amœba they are incapable of performing *all* the functions of life.

Now, a group of similar cells form a tissue, and several different tissues usually go to form an organ. A group of organs, all connected with the same work, form a system. All cells and all tissues contribute to the life of the body as a whole, and the work of a tissue cannot be carried out unless the other tissues are doing their work properly. For example, the cells of the retina would not enable us to see unless the nerve cells, to which they are connected, were able to convey messages from

the eye to the brain. Neither retina nor nerve cells could work if the blood cells did not bring them nourishment: hence there are no isolated water-tight compartments in the body. It is necessary to have a clear idea of the cells of the body, all living their own lives yet having their own particular activities which fit closely into one another. Thus while each cell is a unit, subject to the basic laws which appear to govern life, it is, at the same time, affected by the general state of the body and conditions in one part exerting a marked influence upon those of others. Each must be perfectly healthy and all must work in harmony and precision if the body is to live a full and active life.

Activity is the criterion of life. A man is constantly moving: even when asleep he continues to breathe and his heart to beat. Moreover his body like that of all mammals is always warm, kept at a normal temperature, irrespective of the conditions outside him. He is thus always giving out *energy* and must therefore have internal sources from which to compensate its loss. Life—and energy production—is maintained in the protoplasm of the body—whether it be man or amœba, animal or plant, by a series of physical and

chemical processes which constitute the *metabolism* of the organism. The processes involved are digestion, circulation, absorption, assimilation, oxidation, respiration, and excretion. The word metabolism comes from the Greek, meaning change, and refers to the changes of matter which occur in the body. Metabolism is the sum total of the processes by which an organism performs two main functions:

1. The change of matter derived from food into the actual living substance of its body, building up new units or cells during growth and renewing those which become worn out or injured. This is a constructive change termed *anabolism.*
2. The release of energy (heat, mechanical and chemical), from food substances which is essential for all its activities. This is a destructive process known as *catabolism.*

Metabolism is essentially the same in all living things, but there is one big difference in the process of nutrition in animals and plants. Plants are able to synthesize or build up the complex organic materials from water, and simple inorganic substances from the soil and air. To weld these together they need energy, and by virtue of their green pigment, chlorophyll, they are able to obtain this directly from sunlight. These anabolic processes

accomplished, they proceed to break down the complex substances formed to release the energy which they require. Animals do not possess chlorophyll and consequently must obtain food already synthesized, i.e. as complex organic matter from plants and animals. This food contains a vast store of energy, originally derived from the sunlight in which the plant grew, and the body merely changes this stored energy into heat and into work of different kinds.

Once upon a time the phenomena of heat and fire greatly puzzled the men of science, but towards the end of the eighteenth century it became clear to them that fire was the result of combustion, that is, the combination of the burnt material with the oxygen present in the atmosphere. Coal consists of the remains of great forests which covered swampy regions of the earth millions of years ago. The coal still contains the energy which the trees stored up from the sunlight when they were alive and this coal will burn only in the presence of oxygen which unites with or oxidizes it, causing it to break up into simple substances and at the same time releasing energy in the form of light and heat. It has been proved that animal heat is generated

by an exactly similar process—the burning of food-stuffs in the body. A steam engine is a machine which changes the stored energy of coal into heat energy which can be converted into other forms of energy to do various kinds of work. The living body is also a machine and subject to the same chemical and physical laws which control the change of the stored energy from food into energy suitable for the activities of life. As a machine must be given fuel, so the body must obtain food. Like a machine the body must have oxygen, which it obtains from the air by breathing (respiration). The waste products of combustion in a machine must be removed if it is to continue working efficiently and so also the waste products of combustion in the body must be excreted. Nutrition, respiration, and excretion are thus the vital processes of metabolism in the animal body. All cells need energy and their activities make the body 'a machine in perpetual process of renewal'.

But we should not stretch the simile too far and regard the body simply as an engine and food as its fuel. The nature of the energy exchange between the body and food-intake is rather complicated. To avoid misconception in using the simile, an American

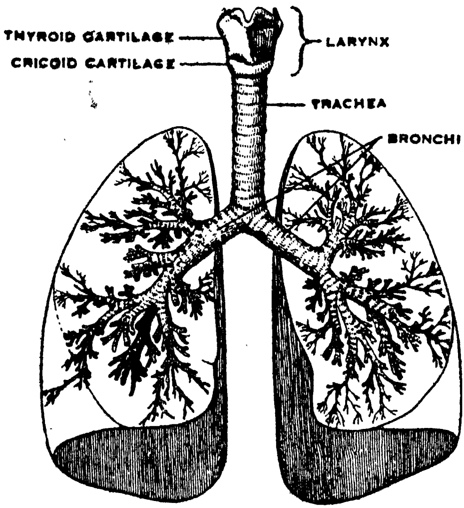
scientist observes: 'It is important to realize that the body is not a heat engine. In a heat engine, heat is the source of the work; in the body, the heat is rather the result of the internal and external work which the body does.' For example, every time the heart beats (which is internal work, because it is done inside the body) or the muscles carry out any action such as lifting a weight (which, since it is done outside the body, is external work), heat is produced. It is this heat which helps to keep our temperature normal. This is another case where one activity of the body (muscular movement) helps another activity (temperature control). Further, we should bear in mind that a machine is an instrument made by man and its activity can be started only when man wishes it, whereas a living body can by itself, and without outside help, carry out its activities. Another very important difference between the living body and a machine is that the organism is able to produce other similar living organisms from its own tissues. In other words, it can reproduce itself.

It is because animals are unable to build up the substances required for energy, growth and maintenance, from simple substances, that

they differ from plants in the way in which they deal with their food. The organic substances which they can utilize as food must be converted into soluble substances before they can be taken into the actual tissues of the body. The process is called digestion. The remarkable mechanism associated with the digestion and absorption of food, i.e. the alimentary or digestive system, will be dealt with in the following chapter. It is sufficient to say here that the digestive system does enable food substances to reach the blood stream, by which they are distributed to all the living units or cells of the body, where they can be used either for building or repair purposes, or as fuel for combustion.

The metabolic cycle can proceed only with the help of oxygen. For without oxygen we cannot burn anything. Since man is a terrestrial animal he must have a skin thick enough to prevent evaporation of the water which forms nearly sixty per cent of the weight of his body. This automatically prevents the intake of oxygen at the outside surfaces which are normally exposed to the air. He has, therefore, a special system of breathing or respiratory organs inside the body which may be likened to a living bellows. These organs are

the lungs, the muscles which surround the chest, and the tubes which lead from the lungs to the outside air. The two lungs are spongy sacs in the chest (or thorax) whose inside surface area is increased to many times that of the body by multitudes of partition walls dividing the lungs into many very small



The Lungs

air sacs. These partition walls are lined with a very delicate moist skin through which oxygen from the air in the sac passes into minute blood vessels running through the walls. The blood then carries the oxygen to all parts of the body. Carbon dioxide is a

waste gas produced when the body burns up the food to give out energy. The blood collects this waste product from the tissues and brings it to the lungs where it passes into the air sac and then is forced out of the body.

The air passages leading from the small sacs in the lungs are very minute but they lead into one another to form two wide tubes, one from each lung, called the bronchi. The two bronchi join together to form the trachea which leads up from the chest to the throat and passages of the nose.

The lungs are always being expanded or contracted by movements of the ribs and the diaphragm, which is a muscular partition under the lungs dividing the chest from the abdomen. When they expand, air is drawn in through the nose and when they contract, air is forced out. The air in the lungs is therefore changed regularly every few seconds.

Since in all these processes, the blood acts as a distributing agent, we should now learn something about the blood system. The blood system is a series of closed tubes of three types: arteries leading from the heart to the various tissues; veins which collect up the blood in the tissues and lead it back to the heart; and capillaries or very minute vessels

with thin walls which branch throughout all the tissues and connect the arteries to the veins.

The blood itself does not come into contact with the cells of the various tissues except in one or two organs. The walls of the capillaries are so thin that some of the liquid of the blood, containing dissolved food substances and oxygen, passes into the tissues. This liquid is called 'tissue fluid' or *lymph*. It receives waste products from the cells, then leaves the tissues by means of small channels called *lymphatics* which lead back into the blood stream. To use a simile of Bogert, lymph acts 'as the middleman between the blood and the tissues, since the blood being enclosed in blood vessels does not come directly into contact with the tissue cells'.

Thus every cell in the body receives a supply of food substances and oxygen from the blood, and they also give back into it the waste products of its processes of combustion. The elimination of these is chiefly the work of the kidneys which are filters removing from the blood, as it flows abundantly through them, the substances which are injurious or unwanted. These are carried in solution by tubes to the bladder and there stored as

urine to be expelled at intervals. These organs form a part of the excretory system.

In all but the simplest animals these three systems—digestive, respiratory and excretory—divide between them most of the essential processes of metabolism, but since the chemical changes involved in the actual release of energy occur in the cells themselves, according to their requirements, there must necessarily be constant communication between these systems and the rest of the tissues. This, as we have seen, is the work of the blood system, which is primarily the transport system. In man, about one gallon of blood is pumped by the heart through a closed system of blood vessels branching through all the tissues, on the average, in rather less than one minute. During its continuous course substances are introduced or removed by appropriate tissues whose functions in the body are thus co-ordinated or made to fit into one another. The heart is a large muscular blood vessel which acts as a double pump. Through the right side passes blood which has returned from the whole of the body and is, therefore, deficient in oxygen. It is then pumped straight to the lungs and is returned, enriched in oxygen, directly to the left side

of the heart, whence it is pumped under great pressure to all parts of the body.

Perhaps the most outstanding characteristic of the animal kingdom is that of movement. This again is associated with the animal's inability to use simple substances from soil and air and the resulting necessity for seeking or drawing in appropriate food. The skeleton of man is a scaffolding which supports his body, raising it from the ground. It is a system of separate bones formed from hard material manufactured out of food-stuffs by living cells. The bones are held together by bands of tough fibrous tissue called ligaments and fit into one another by smooth surfaces allowing movement. Movement is effected by the muscles which have the peculiar power of contraction: without altering their volume they can change their shape, alternately shortening or elongating, and so altering the relative positions of the bones to which they are attached. To do this they need energy and it is in them that the greatest release of energy to the body occurs. But it should be remembered that all cells require energy to do their particular work.

The function of the nervous system is to co-ordinate and control all the activities of

these elaborate systems of organs in the body. From the brain and spinal cord radiate tough white strands of tissue, the nerves, which are distributed to all the tissues. They act like telephone wires along which flash messages or nerve impulses. *Sensory* impulses occur when information is brought to the brain and *motor* impulses are caused when the brain sends out an appropriate order of action. The sensory impulse is caused by a 'stimulus' and the motor impulse causes a 'response'. Thus no organ acts by itself; before a motor impulse is sent to a particular organ it has been checked in the central exchange of the nervous system against the existing situation in other parts of the body. The central exchange consists of the brain and the spinal cord which is attached to the brain and protected by the backbone. In this controlling process, the nervous system is helped by the endocrine organs (e.g. thyroid and adrenal glands) which manufacture or secrete and pass into the blood minute quantities of chemical substances which, in circulating, act as messengers to certain specific organs or tissues. Not only this, but with the help of the sense organs bringing information from the world outside, the brain is able to make decisions

by which the body may adjust itself to external conditions. Man owes his dominance over all living things to his powerful brain which permits him not only to select and respond to the most important of several impulses if they should be received at the same time, but also, profiting by experience, to make far-reaching decisions extending into the future.

We may now state the relations between the structure (that is, anatomy) and the function (that is, physiology) of the various systems described above.

SYSTEMS		MAIN FUNCTIONS
Skeleton	..	Support of the body.
Muscular	..	Movement, i.e. both locomotion and transport within the body.
Circulatory	..	Conveying of nourishment to various parts of the body.
Respiratory	..	Breathing.
Nervous	..	Conduction of impulses thus controlling and co-ordinating activity.
Digestive	..	Feeding.
Excretory	..	Getting rid of waste products.
Endocrine	..	Controlling activity of tissues by chemical means.

Each and all of these systems are necessary for the daily life of man. Together with the reproductive system they constitute the living

body which is thus a machine of parts adapted to perform special functions. This machine is built up and maintained by material introduced in the process of nutrition, and is activated by energy released from these substances by catabolism. Thus, the problem of nutrition is the pivot around which revolves the whole question of the health and efficiency of the body and mind of man.

Before proceeding to discuss the actual processes of nutrition, we should consider briefly what different food constituents the body needs and in what food-stuffs they are available.

Chapter III

WHAT IS FOOD?

All living things have pretty much the same chemical composition. If the human body is chemically analyzed, it is found to consist of much the same elements as the food-stuffs consumed. At the Paris Exhibition in 1937 there was an interesting show-case containing bottled specimens of the elements, except fluorine, that make up a human body, in their correct proportions. It is estimated that 'in the body of a woman of average size there are nine gallons of water; enough oxygen to fill eight nine-gallon barrels; enough carbon to make nine thousand graphite pencils; enough phosphorus to make eight thousand boxes of matches; enough hydrogen to inflate a balloon capable of raising the whole body to the top of Snowdon; enough iron to make five tacks; enough salt to fill six ordinary salt cellars; and four or five pounds of nitrogen'.[1]

Likewise if we analyze our food-stuffs, the

[1] Macfie, R. C., *The Body*. (Ernest Benn)

chemical composition shows the presence of all these elements in varying quantity. It is through food, air and water that the body has to be kept furnished with all the substances without which it could not perform its functions. Thus, calcium is a main constituent of the bones; sodium, potassium, iron and other elements find their way into the blood. Phosphorus is a necessary constituent of every cell and nerve tissue, and iron of the hemoglobin (the colouring matter) of the red blood cells.

There are several ways of classifying the food we consume. The classification based on the chemical compositions divides it into six different groups, namely, carbohydrates, fats, proteins, certain inorganic substances, vitamins and water. These are all essential to the body. Although each of these food constituents has a specific part to play, they must be regarded as a whole. Just as in a chain each link maintains the continuity of the whole chain, so does each different food substance contribute to the nutrition of the body.

There is no perfect food that can alone fill all the needs of nutrition. It would have to supply adequate heat and energy for muscular

work; provide material to replace wear and tear of tissues and ensure the presence of those food substances which increase the resistance of the body to infections. It is therefore important to bear in mind that not only do foods vary in ther chemical compositions and in the use to which they are put within the body but that the standard of food requirements must be something higher than merely the satisfying of hunger.

CARBOHYDRATES

All of the food carbohydrates, except milk-sugar, are found in the plant kingdom. Cereals, fruits, vegetables are the sources that supply carbohydrates.

These are composed of carbon, hydrogen and oxygen. Sugar and honey are *pure* carbohydrates, but in many food-stuffs, such as rice, wheat, millet, peas, beans, potatoes, fruits and milk, they exist mixed with other substances. Of all food constituents carbohydrates are the most readily converted into energy and, therefore, they are regarded primarily as energy-producing constituents. Cellulose is the husk element of grains, fruits and vegetables. It is a carbohydrate but has no food value because it cannot be digested; but its

mechanical effect upon the digestive process which is described in the next chapter is of considerable importance.

Carbohydrates are classified under three groups on the basis of their structure:

1. *Monosaccharides* are just simple sugars, such as glucose, fructose, which cannot be split into any simpler forms. They are extremely soluble.

2. *Disaccharides* are sugars formed by the combination of two molecules of monosaccharides. Cane sugar, lactose and maltose belong to this group and they must be broken down to monosaccharides before the body can use them.

3. *Polysaccharides* are substances like starch and cellulose. Rice, wheat, barley, millet, sago, tapioca and potato are some of the common sources of starch.

There are as many as five kinds of sugars found in our foods. Sugars that are found in the sap of different plants and in the juices of all kinds of fruits are known as glucose and fructose. Glucose is one of the main constituents of honey. Of these simple sugars, monosaccharides, we must give glucose a place of honour because it is in this form that sugar is found in the blood. The liver converts glucose, as we shall learn in the next chapter, into a substance known as glycogen. This stored glycogen is reconverted into

glucose which is an important fuel of the body.

Sugars obtained from the sap of the sugar-cane or from sugar-beet are called sucrose. Lactose is milk-sugar and maltose is found in sprouting grains. These more complex sugars, disaccharides, cannot be utilized by the body as such and must be transformed into simpler forms.

As food-stuffs belonging to the group poly-saccharides contain starch and cellulose, they require cooking. Heat breaks the walls of the cells and water gets into the starch grains. That is why rice grains swell and get soft by cooking. Starches are incompletely soluble in water and tasteless, but they are easily converted into sugars, which are soluble, in the digestive process.

By far the largest bulk of our food consists of carbohydrates because they are the most economical source of energy; but not all carbohydrates can be utilized for energy purposes.

FATS

Fats, like carbohydrates, are composed of carbon, hydrogen and oxygen in different pro-portions. Fatty foods furnish twice as much

heat per gramme as the same quantity of carbohydrates and proteins.

Nearly all foods contain some proportion of fats; but ghee, butter, nut butter, coconut oil, groundnut oil, fish oil, and lard are some of the familiar examples of foods consisting almost entirely of fat. Whole milk and cream contain fats in addition to many other constituents. Fats are thus derived from both animal and vegetable sources. Based on their varied melting points, they are divided into at least fifteen different groups. The fats which have a low melting point, as in the case of milk, cream, butter and egg-yolk, are easily digested; on the other hand, those with a high melting point, for example, mutton fat or *charbi*, are not so easily digested and absorbed. Fats are insoluble in water.

In addition to furnishing the most concentrated kind of fuel, fats serve as a *reserve* energy supply and therefore they may also be regarded as a protective food constituent. Butter, cream, unadulterated ghee are rich in 'good' fat because they contain an important food constituent called vitamin A. Coconuts, nuts of all kinds and soya beans supply fats that are of value to the body.

PROTEINS

Proteins differ from carbohydrates and fats in that they contain nitrogen in addition to the other three elements, namely, carbon, hydrogen and oxygen. The proteinous foods are, therefore, the only source through which the body can obtain nitrogen, the substance necessary for growth, maintenance and repair of body tissue. It is an essential constituent of both plant and animal cells. Consequently there can be no life without this element.

But proteins are of complex structures and cannot be utilized by the body unless they are split into simpler forms. These simpler nitrogenous compounds are called amino-acids which are component parts of proteins and hence of protoplasm itself. While the number of proteins is large, there are not more than twenty-five constituent amino-acids, which are regarded as building stones of proteins.

Proteins are derived from animal as well as vegetable sources; but they exist in various forms, such as gluten of cereals, legumin of pulses, casein of milk and albumen of eggs. Proteins differ in food value according to the amounts and types of amino-acids which they contain. Of the twenty-five or so amino-

acids known to occur in proteins, six or seven are essential as constituents of the diet because the body is unable to obtain them from other substances. All animal flesh, egg, milk, cheese, wheat, beans, peas and nuts are among the foods which contain 'good' proteins, that is, proteins which furnish us best with essential amino-acids. We may mention one or two 'bad' proteins. The protein of maize, zein, contains none of the essential amino-acids and therefore maize is an inferior cereal. Take another example: gelatin is low in nutritional value because it does not supply the kind of amino-acids the body cannot make from other sources. There are a number of vegetable proteins which resemble gelatin, and that is why so much importance is attached to the use of proteins derived from animal sources.

The amount of protein in different foods varies greatly. Italian pine kernels, for example, contain thirty-three per cent protein, while ripe apples furnish not more than ·1 per cent, and soya bean contains as much as 43·2 per cent but sago only ·17 per cent.

INORGANIC SUBSTANCES

We have seen that the body contains several inorganic elements which are kept

supplied through foods. They are chiefly needed for the building of the body structure; they are not, we should remember, a source of energy to the body as they cannot be burnt, but are an essential part of its tissues and organs. There are some twenty elements which enter into the composition of tissues, but in varying degrees of importance. Each element serves its particular purpose. Thus, calcium is necessary for the satisfactory working of the nerves and muscles; chlorides for the production of hydrochloric acid in the stomach, so essential for protein digestion, and so on. The most familiar example of an inorganic substance which we consume is common salt.

Let us now try to understand why these elements which do not undergo any change in the process of nutrition are regarded so essential for the health of the body. The cells of the body are unable to work properly unless the tissue fluid which surrounds them contains certain inorganic substances. For example, the heart will not beat in the absence of potassium in the blood and the nerves work abnormally if too much or too little calcium is present in the tissue fluid. We may sum up these facts by saying that the inorganic

substances serve to maintain the proper fluid environment for cellular activity. The blood and tissue fluids should be slightly alkaline in reaction. The inorganic elements of our foods left as residues of the processes of metabolism are known as the ash constituents. Some of the acid-forming foods, such as eggs, meat, bread, cereals, pastries, prunes, and plums, leave behind the residue containing acid products and deplete the alkaline reserve of the blood if they are in excess. There are also base-forming foods, such as vegetables, apples, oranges, pears, nuts, milk, etc., which yield a considerable alkaline material. In order to ensure the maintenance of a slight alkaline reaction for the best health of the tissues, it is necessary that a normal diet should have adequate base-forming foods.

We will consider here four of these inorganic substances: calcium, phosphorus, iron and iodine. They are supplied under ordinary circumstances through our diet, but foods vary extremely in providing them in appreciable amounts. From radishes, onions, carrots, cucumbers and green vegetables we get a fair amount of calcium. The milled cereals, meat, fat and sugar are poor in calcium; but milk is the richest source of this substance.

It is essential that during the period of growth children should receive an adequate supply of calcium. Boys and girls require three to four times as much calcium in proportion to their body-weight as is required for the nutrition of adults. Calcium must be in an easily available form, and the value of milk is to a great extent due not only to its high calcium content but to its availability. Calcium from vegetable sources is less easily absorbed than that from animal sources. It should be noted that the calcium of vegetables is better assimilated by the adult than by the child. A diet consisting of milk, cheese, eggs, vegetables and nuts should ensure an adequate supply of calcium.

Phosphorus, an essential element in cell nuclei, occurs in food in both organic and inorganic forms. It combines with calcium in building the bony structures of the body. Phosphates play an important role in maintaining the tone of the actively functioning tissues of the body. Eggs, meat, fish, milk, legumes and nuts are some of the common foods which contain a fair amount of phosphorus. Whole cereals are rich in phosphorus but not in calcium.

Iron is an essential constituent for the formation of the red colouring matter of the blood, which acts as a carrier of oxygen in the body-cells. Since there is little reserve of iron in the body, it has to be supplied through food. The yolk of eggs, green leaves, nuts, whole grain, legumes and dried fruits are among the common foods which supply an appreciable amount of iron.

Iodine is necessary for the proper functioning of the thyroid gland. Sea-products are the main source of this substance but it is present in wheat, millet, carrot, goat's milk and condiments such as cloves, ginger and black pepper.

Other essential inorganic elements, such as potassium, magnesium, and sulphur are normally present in all ordinary food-stuffs in amounts necessary for the body. We have mentioned that chloride is needed for gastric secretion. Apart from the natural sources of supply, we get plenty of chloride from the intake of common salt (sodium chloride). It improves the flavour of all vegetables, cereals, eggs, etc. and maintains the balance of other mineral constituents. For example, much potassium salts are ingested in vegetable food and therefore there is a need for common salt in order to supply adequate sodium,

since the amounts of sodium and potassium and certain other substances in the tissues balance one another.

VITAMINS

Food materials are not so simple as they appear. Scientific men of the eighteenth century thought that there was only one kind of food substance derived from all foodstuffs, and that it alone sufficed for the nourishment of the body.

By the beginning of the nineteenth century, the eminent French physiologist, Magendie, came to a different conclusion and demonstrated the existence of several kinds of nutrient principles in foods. Since then much knowledge has been accumulated concerning the nature and needs of the nutrients which form the greater part of a diet, such as carbohydrates, fats, proteins and inorganic substances. Yet the whole story of the nutritive value of foods was not complete and something was found to be lacking even in a diet which, from a standpoint of earlier theories, might appear to be complete. Actual experiments showed that animals could not live on a mixture of *pure* carbohydrates, fats and proteins. Even when the necessary

inorganic substances were supplied, animals could not flourish. But an addition of a small quantity of milk to the mixture of pure foods made a great difference. What is it in milk, scientists began to enquire, that exerts such a profound influence on nutrition? Further investigations revealed the existence of a number of substances now known as *vitamins* and they are designated by letters of the alphabet. The name is derived from the Latin word *vita*, meaning life, because they are essential to life.

There are several kinds of vitamins and each seems to have its own definite function. One kind helps the formation of bones and teeth; another strengthens the nervous system; and again another is essential to the growth and development of the body. The absence or inadequacy of vitamins affects health, growth and reproduction; but if the diet includes plenty of milk, butter, eggs, fish, fruits and leafy vegetables there should be no risk of vitamin deficiency. These substances are present in small but varying amounts in a wide range of food-stuffs; but they undergo no alteration in the digestive tract and produce no energy themselves. Physiologists and physicians have adduced sufficient evidence to

FOOD	Protein	Fat	Carbohydrate	Calcium	Phosphorus	Iron	Iodine	Vitamins		
								A	B	C
Apples ..			♂					⊙	⊙	⊙
Beans, string (french) ..	♂		⊙	⊙	♂ ☿	♂	♂	♂	♂	♂
Bread, wholemeal (atta chapatti)	⊙		☿		⊙	⊙		⊙	⊙	
Butter or ghee ..		☿						☿		
Butter substitutes (peanut butter)		☿								
Cabbage, raw ..			⊙	⊙		♂	♂	⊙	☿	☿
Cabbage, cooked			⊙	⊙		♂	♂		♂	♂
Carrots ..			♂	♂		♂		♂	♂	♂
Cauliflower ..			⊙	☿	☿		♂	⊙	♂	⊙
Celery stalks ..	⊙		⊙	♂	♂	⊙	⊙			
Cereals, dry (food grains, whole)	⊙		☿		⊙	⊙			♂	
Cheese ..	☿	☿		☿	♂		♂	♂		
Cream ..		☿						☿	♂	⊙
Eggs ..	☿	☿		⊙	♂	☿	☿	♂	⊙	
Fish	☿	⊙ ♂			♂		☿			
Figs (dry) ..				♂	⊙	♂				
Honey ..			☿							
Jam			☿							
Lettuce ..				♂	♂		♂	♂	♂	☿
Meat ..	☿	⊙ ♂			♂	⊙			♂	
Milk ..	♂	☿	♂	☿	♂	⊙	☿	⊙	♂	⊙
Nuts ..	♂	♂		♂	♂					
Oranges ..			♂					⊙	♂	☿
Peas	♂		♂	⊙	⊙	♂		♂	♂	
Potatoes ..			☿	⊙		⊙			⊙	⊙
Prunes ..			♂	⊙		⊙		♂	♂	
Rice (polished) ..			☿							
Spinach ..			☿	♂	☿	☿	♂	☿	⊙	⊙
Sugar ..			☿							
Tomatoes ..			⊙	⊙	⊙	♂		♂	☿	☿

☿ = Excellent, ♂ = Good, ⊙ = Fair.

show how the body is affected if our food does not contain an adequate supply of vitamins. In the course of our study we will come to know how their deficiencies affect health and well-being.

Of the vitamins known we shall confine our study to six, namely, A, B_1, B_2, C, D and E. Each one has a specific role in normal nutrition. It is interesting to note that these essential food substances are always found in *fresh* food-stuffs. One class of vitamin is obtained from butter fat, another from a by-product of the milling of rice or wheat, and yet another from green chillies, fresh fruits, etc. But these different classes of vitamins, to quote McCarrison, 'like other essential constituents of the food, are not to be regarded as independent of the assistance derivable from their associates in the maintenance of nutritional harmony'.

Vitamins are divided into two main groups, namely, water-soluble and fat-soluble. The vitamins B_1, B_2 and C are soluble in water, and A, D, and E in fat.

Vitamin A is found in fatty foods as it is soluble only in fats. Whole milk, butter, cheese, eggs, liver, and cod-liver oil are the chief sources of vitamin A. It is a substance

related to carotene, the yellow pigment of which is present in some vegetables and fruits, and 'the pigment carotene appears able to fulfil the physiological functions of vitamin A in the body. Vitamin A requirements can thus be covered by the consumption of a suitable vegetable diet. Leafy vegetables such as spinach, lettuce, cabbage, amaranth leaves, coriander leaves, drumstick leaves, celery leaves, and ripe fruits such as mangoes, papaya, tomatoes, oranges, etc., are rich in carotene.'[1]

Vitamin B, originally regarded as a single substance, is now divided into a number of factors. We shall, however, confine our study to two of these, namely, vitamin B_1 and vitamin B_2. Vitamin B_1 is a water-soluble substance found in most natural food-stuffs. It is abundant in the outer layers of rice and other cereals. Unpolished rice and other grains, yeast, egg-yolk, nuts, legumes, green vegetables and fruits are some of the rich natural sources of this vitamin.

Vitamin B_2 is less soluble in water but more heat resisting than B_1. Yeast, egg-yolk, liver,

[1] *Nutritive Value of Indian Foods and the Planning of Satisfactory Diets*: Health Bulletin, No. 23, 1937. (Nutrition Research Laboratories, Coonoor, S. India.)

dried peas, beans, green leafy vegetables and milk products contain vitamin B_2. Cereals and root vegetables are not good sources of this vitamin. Maize is almost totally deficient in it and therefore a disease known as pellagra breaks out among those maize-eating people who are unable to make up the deficiency by consuming a mixed diet.

Vitamin C is another water-soluble substance and is easily destroyed by ordinary cooking. Fresh fruits and green leafy vegetables are the best sources of vitamin C, but as it is destroyed by heat and disappears from the foods containing it if they are allowed to grow stale, we must have them fresh and preferably eat them raw. Sprouted pulse is a good source of vitamin C.

Vitamin D is, like vitamin A, fat-soluble and is therefore found in fatty foods. Cod-liver oil and other fish-liver oils are rich in this substance. It is found that in its absence from the diet, the body cannot fully utilize calcium and phosphorus which are necessary for bone formation. Human skin contains a substance which may be transformed into vitamin D by sunlight. This explains how rickets and similar bone

deformities may be cured by carefully directed exposure of the skin to sunlight.

Vitamin E is essential for reproduction. The germ of the wheat grain is a rich source of vitamin E and it is not easily destroyed by heat.

WATER

Lastly, we need water. Water is a compound of hydrogen and oxygen. Nearly two-thirds of the body-weight of any normal human being consists of water. It is not an actual source of energy, but it acts as a solvent and aids in digestion and absorption of foodstuffs. It sustains the proper concentrations of the food substances within the body-cells and assists the removal of waste products. Practically every reaction which takes place in the body following the ingestion of food requires water.

It has been demonstrated that a healthy and well-nourished person can fast for as many as forty days without permanent injury provided he receives an adequate supply of water; but he cannot fast for more than six days without water. A physiologist found that starving pigeons died in four to five days, while those allowed water and no food lived

twelve days. Pigeons fed *dry* food died in about four and a half days.

The amount actually needed by the body depends on climate, diet, and occupation; and the need is indicated by thirst. In our foodstuffs there is much more water than solid matter, and the body gets a fair amount of water from the oxidation of ingested diet, as when food substances are oxidized, water and carbon dioxide are produced.

Each and all of the six classes of food we have mentioned above are essential for the maintenance of what the physiologists call metabolic balance. If diet is deficient in any of these food constituents, ill-health is likely to result; on the other hand, abnormal accumulation in the body of any of these constituents likewise may produce undesirable effects. In the next chapter we will study what the processes are by which the body makes use of food and is nourished.

Chapter IV

THE PROCESSES OF NUTRITION

'Man is, first of all, a nutritive process', declares an eminent physiologist. This means that, of all factors that are essential for the growth and maintenance of the body, the greatest influence is exercised by nutrition. We have seen that the body functions through the energy released by the different food constituents. If and when nutritional influences are withheld or food becomes deficient either in amount or in quality, that harmonious development of the structure and function of the body on which our health depends is interfered with. Indeed, natural health comes from the balance of all the processes of the body.

It is not enough merely to consume food of nutritive value: the food must be actually digested and absorbed in order to furnish energy to the body. Since the process of digestion and absorption have a direct bearing upon nutrition, we shall try to understand the mechanism by which food-substances are used by the body.

Mr Pecksniff, a character in Dickens's *Martin Chuzzlewit*, was right when he said: 'The process of digestion, as I have been informed by anatomical friends, is one of the most wonderful works of nature. I do not know how it may be with others, but it is a great satisfaction to me to know when regaling on my humble fare that I am putting in motion the most beautiful machinery with which we have any acquaintance. I really feel at such times as if I was doing a public service . . . '

According to Paracelsus the nutritive process was confined to the stomach where resided an ' archeus ' and it was there the food was separated into two categories, the good portion for the use of the body and the bad for removal (or excretion). But the process is not so simple as that and nutrition is something more than the supply of food and drink to the body. Ample fresh air, sunshine, a reasonable amount of physical exercise and a contented mind are no less important than sensible diet. It has been observed that the stomach of an angry or frightened animal ceases to work and remains in an inactive or relaxed condition until the animal is pacified. The moral is, we must not allow

ourselves to be agitated while eating our meals.

The story of how physiologists came to study the process of digestion in the human body is interesting. It happened that on 6 June, 1822 a Red Indian traveller in Canada shot himself in the abdomen through the accidental discharge of a gun. A young United States Army surgeon, Dr William Beaumont, dressed his wound which healed in due course but left a hole in the abdominal wall. Through this hole the surgeon was able to study the changes that took place as food entered the stomach—and his experiments led to the discovery of what is called gastric juice, the digestive juice which the stomach produces.

But it is not this juice alone which brings about conversion of the complex food-stuffs into such forms as make them easily absorbed into the bloodstream. We shall see that various other kinds of secretion are involved in the processes of digestion and absorption.

The mechanism of digestion is not the same in all animals. Birds, for example, have no teeth at all. Therefore they swallow foods which enter into a milling machine called the gizzard where food substances are

disintegrated and digested. But we digest our food mainly by the use of acids, enzymes and such chemical products.

What are these enzymes which play an important part in all digestive processes? Enzymes are produced by the living cells of the various glands.[1] Each enzyme has a specific function, that is, it acts upon only a definite food constituent and requires certain distinctive conditions for the fulfilment of its task. There are about a dozen of these digestive enzymes which are concerned in speeding up the digestive changes of the food substances.

MASTICATION

The first part of the digestive processes takes place in the mouth where food is macerated by the teeth and movement of the jaws. The process is known as mastication. The food is moistened and made alkaline by saliva secreted by a number of glands [2] whose

[1] A *gland* is an organ the function of which is to produce or secrete some fluid which the body requires. The secretion leaves the gland and reaches its destination through a tube called a *duct*.

[2] Three main pairs of salivary glands are called the *parotids* (Gr. near ear), *sublinguals.* (L. under tongue), and *submaxillaries* (L. under jaw).

activities are controlled by nervous impulses. The secretion of saliva may be accelerated by various stimuli derived from mechanical, chemical and even psychical sources. When a child puts its finger or a sucker into the mouth, the glands produce a copious, thin, watery secretion; or upon the intake of any acidic, pungent or saltish substance, the mouth 'waters'. The nature and amount of the secretion depends to a certain extent upon the kind of stimuli received by the glands as well as upon the individual. It has been demonstrated that 'when articles of food are placed near a hungry subject, the glands secrete a thicker saliva with a much higher mucin content'. Thus we see that the secretion of saliva may be increased by various stimuli derived from the touch and taste of objects in the mouth and the sight or even thought of food.

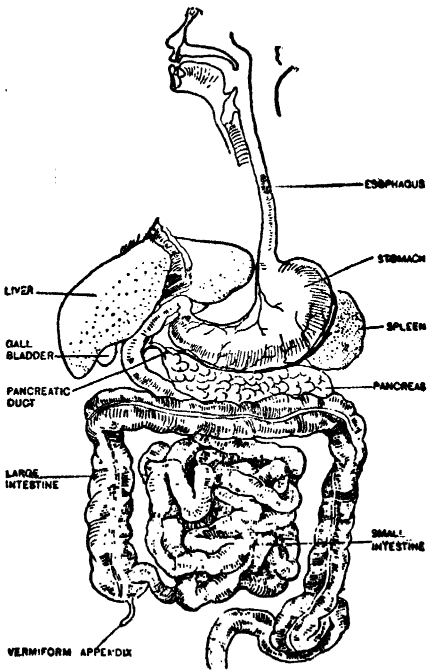
The flow of saliva varies to a certain degree with the sort of food taken into the mouth. Thus, dry solid food excites a larger salivary secretion than food containing an abundance of water.

The enzymes found in salivary secretion aid in the process of digestion but the digestion carried out by the saliva affects only the

carbohydrate content of the food intake. The salivary enzymes cannot act upon a bulk of carbohydrates within the short space of time the food is being masticated. A rich carbohydrate meal therefore requires proper mastication. This of course applies to all food, which must be thoroughly broken up into small bits in order to expose the largest possible surface area to digestive juices later. The lubricating action of saliva is important. A well-chewed mouthful of food becomes slippery and slides down to the stomach in a few seconds. Since the function of the saliva is to prepare the food for further processes of digestion, the question of thorough mastication is of great importance. It helps the assimilation of food because adequate mastication prolongs the time during which the food touches the mouth and stimulates the salivary glands and thus increases the flow of their secretion. It is therefore recommended that something dry or crisp should be included in each meal.

Proper mastication and the stimulation derived from tasty and agreeable food prepares the second stage of the digestive process by accelerating gastric secretion, that is, the production of gastric juice, the fluid secreted

by the many small glands which line the stomach. The food is swallowed by a complex muscular act of the throat accompanied usually by an automatic closing of the apertures to the trachea and nose so that it cannot



The Alimentary Tract

'go the wrong way'. Thus the food passes from our conscious control into those regions whose activities we shall now try to understand.

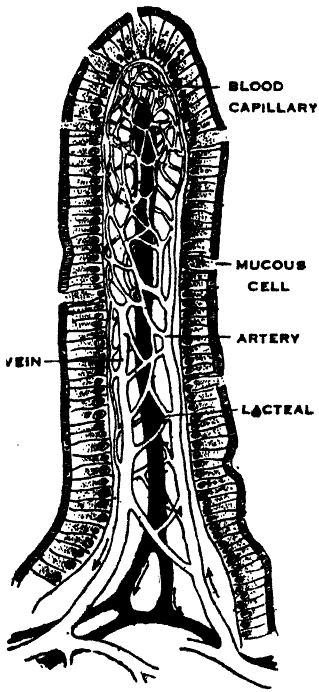
DIGESTION AND ABSORPTION

The two fundamental aspects of the nutritive process are digestion and absorption. The conversion of food in the body into simplified soluble substances which can be absorbed into the blood and lymphatic system is what is meant by digestion. Both digestion and absorption involve a series of processes carried on with the aid of various kinds of secretions in a number of specially adapted organs known collectively as the alimentary tract.

Perhaps we should say a few words about the anatomy or structure of this alimentary tract. It consists of the mouth, the pharynx (throat), the oesophagus, the stomach, the small intestine and the large intestine or colon. The entire length of the alimentary canal in man is twenty-five or thirty feet, of which the small intestine alone has a course of about twenty feet. It is a much coiled organ and joins with the large intestine at a place known as the *caecum*. There are also a number of accessory organs, such as the pancreas and liver, which are associated with the alimentary tract. The various kinds of secretions which are required to prepare food for absorption come from them. These essential processes

of digestion, unlike those of respiration and circulation, do not take place all the time or at regular intervals; for they only follow the taking in or ingestion of food.

Absorption is the process by which the final products of digestion pass through the wall of the small intestine into either the blood or lymph stream which circulates inside the wall. Like the rest of the digestive tube, the intestine is lined with living cells called *epithelial cells*. But here the absorptive surface area is greatly increased by a large number of *villi*[1] which are minute finger-shaped moving structures. These can absorb digested food on all sides. Cells take what they need from the substances found in the



[1] Each villus is provided with capillaries, artery and vein, and in the centre a lymph vessel called a lacteal.

lymphatic system and blood stream. Most of the simple components resulting from food digestion pass through the wall of the villi directly into the blood circulation; but fatty substances are absorbed into special delicate lymph vessels called lacteals in the surface of the small intestine and are carried some distance in the lymphatic system before they eventually enter the blood stream.

In addition to those already mentioned there are other vital secretions associated with the process of digestion. Unlike those glands which possess ducts there are certain endocrine[1] glands which discharge their secretions directly into the blood and lymph channels. These glands are therefore called ductless glands. The endocrine secretions or hormones[2] not only excite and control metabolic activities in the whole organism but exercise a profound influence in co-ordinating the activities of different organs and thus maintaining the physiological efficiency of the body. These ductless glands constitute a remarkable chemical mechanism for regulating growth

[1] The word 'endocrine' comes from a root which means 'separate within'.

[2] The word 'hormone' is derived from a Greek verb meaning 'to excite' or 'to set in motion'.

among many other bodily activities. Therefore any interference with their proper functioning in children may especially result in retarded growth. The flow of gastric, intestinal and pancreatic secretions or those from other sources is, to some extent, dependent upon the proper secretions of the endocrine glands whose constituents are derived from the food accessories. To cite an instance, iodine in the food is essential for the proper functioning of the thyroid[1] gland.

THE JOURNEY OF 'BOLUS' THROUGH THE ALIMENTARY TRACT

The food reduced to a semi-solid mass called the 'bolus', is drawn through the oesophagus, which is a muscular tube leading from the mouth to the stomach, by the movements of contractions and relaxations of the muscles of the oesophagus wall. It remains in the stomach for some hours depending upon the nature of food intake.

We should acquaint ourselves with some of the characteristics of the movements of the alimentary canal, known as peristalsis. It is

[1] Thyroid (Gr. shield+form).

'a ring of contraction which travels at a regular pace down the length of the stomach. The rate is about three waves a minute, and each takes about twenty seconds to pass from end to end'. But it is not quite possible to say what the *normal* movement would be because it varies greatly, not only with the individual, but from time to time in the same individual. Any disturbance in the nervous system may interfere with peristaltic activity, and hence in the digestive process.

Peristalsis occurs throughout the length of the alimentary canal but its speed, intensity and the time-interval between the waves of contraction vary in different parts. For example, these movements in the large intestine tend to delay the passage of food and to promote its disintegration. We shall refer to these movements again when we describe the working of the large intestine.

The digestive process in the stomach is accomplished, in the main, by the secretion from thousands of microscopic glands in the wall of the stomach of gastric juice containing an acid called hydrochloric acid, which makes the food acid and so stops the digestive action of saliva which can only take place in slight alkali. The acid kills any bacteria present

in the food and helps to disintegrate the proteinous substances in preparation for the action of the enzymes in the small intestine. It is important to bear in mind the two main factors in gastric digestion, namely, the amount of the gastric secretion and gastric peristaltic movements by which the bolus is well mixed with it. The secretion and function of the gastric juice are dependent upon various factors such as hunger, nature of the food, the sight, taste or even thought of food and the state of mind. The famous Russian physiologist, Pavlov, has demonstrated that the flow of the gastric juices is started by impulses which have their origin in the mouth and nostrils. By merely allowing a hungry dog to smell food, Pavlov was able to obtain nearly 100 c.c. of gastric juice in an hour and a half. The climatic conditions also effect the gastric secretion. It is found, for example, that its total acidity and chloride contents are low in the Tropics and that for the purpose of stimulating this secretion various condiments and spices are used in tropical dietaries. The more appetizing the food, the larger the amount of secretion.

Through gastric digestion, the bolus is now changed into a semi-fluid uniformly mixed

mass called chyme enabling it to pass through the orifice of the pylorus—gate-keeper of the stomach—on its way to the small intestine. The opening of the orifice appears to be controlled by the size of the disintegrated food particles as well as by the nature of the food itself. Carbohydrates begin to pass out early but fats linger in the stomach for some time. Under healthy conditions the average meal should have left the stomach completely in about four to five hours. A diet rich in fat or highly concentrated food retards the process of emptying; but this retardation may be useful, in that it keeps hunger at bay since the sensation of hunger is probably related to the amount of food in, and movements of, the stomach.

On entering the small intestine the chyme, which is acid, receives three alkaline liquids: the pancreatic juice (from the pancreas), the intestinal juice (from the glands in the walls of the intestine itself) and the bile (from the liver). The liver continuously secretes bile which is transported to the intestine through a duct. It is not, properly speaking, a digestive secretion since it contains no enzymes but it assists the action of the enzymes of the pancreatic and intestinal juices in several

ways. First, its alkalinity helps to neutralize the acid of the chyme and the enzymes of this part of the alimentary canal work best in alkali. Secondly, bile has the power of breaking up fat into very small droplets—a process known as emulsification—which can be easily attacked by enzymes. Also the enzymes of pancreatic juice act more rapidly in the presence of bile but it is not exactly known why this is so.

Several kinds of enzymes are present in the pancreatic juice and these attack proteins, starches and fats, splitting them through a number of stages into such simpler components as would render them readily absorbable.

In the upper portion of the small intestine the peristaltic activity is sluggish; for it is at this stage that the largest part of the processes of digestion and absorption has to be accomplished; it is here that the pancreatic juice containing a complete set of digestive enzymes is able to split up partially digested food substances and also those that may have escaped being acted upon in the earlier stages of the process. In order to achieve a high degree of efficiency in digestion and absorption,

the food substances are not hurried along the lower portion of the intestine; but are chopped and churned very thoroughly as they are carried slowly by peristaltic waves along the twenty odd feet of the small intestine. This irregular progress of one meal takes about three hours, at the end of which the insoluble remains are swept into the large intestine, where exists 'perhaps the most rapid peristaltic evacuative power in the gastro-intestinal tract'.

With the arrival of the remnant of the chyme in the large intestine, digested food comes to its journey's end. It is estimated that in a normal digestive process as much as 95 per cent of the food-stuffs is digested and absorbed by the time the large intestine receives the food residues. The function of the large intestine is to secrete a slimy protein substance, mucus, as a lubricant, to excrete salts (particularly calcium, iron and magnesium), to ferment cellulose (which is acted upon by bacteria) and to absorb water from the residue. The chyme when it enters the large intestine is still in a fluid state but considerable amounts of water are absorbed from it and it becomes a semi-solid consistency.

Here the mechanical movement is not confined to the usual peristaltic motions; for the first time anti-peristaltic waves are observed. That is, movements which force the contents of the intestine backwards in the direction of the mouth, operate. But these movements do not last long and are followed by normal forward waves causing the intestinal contents to move backwards and forwards. This ensures a thorough absorption. During the process the chyme is subjected to dehydration (i.e. water is removed) and the residue is thrown into that part of the intestine known as the transverse colon. The chyme has now become faecal material or 'faeces', consisting of undigested food-particles, the remains of digestive secretions, cells torn off from the walls of the intestine and myriads of bacteria mostly dead. This material is then driven out of the body through the action called defaecation. The normal passage of food from the time of its ingestion to evacuation requires approximately thirty-six hours.

We should now enquire what happens to those six food constituents which are needed for the growth and maintenance of the body and for the regulation of its functions.

DIGESTION OF CARBOHYDRATES, FATS AND PROTEINS

Let us follow the digestion of the carbohydrates; that is, starch, sugars and cellulose. They are, as already mentioned, digested by the enzymes of the saliva and then by those of the pancreatic and intestinal secretions. During mastication they receive an enzyme amylase or ptyalin which breaks up or hydrolyzes starch into maltose and dextrin.

The action goes on for a time even for as long as half an hour, when they reach the stomach but further chemical changes are stopped as soon as the contents of the stomach become acid because the salivary enzymes cannot operate in acid media. The gastric juice contains no enzymes which act on carbohydrate. That which remains undigested passes from the stomach to the small intestine where await other enzymes secreted by the pancreas and glandular epithelium of the small intestine for hydrolyzing carbohydrates. The pancreatic juice contains an enzyme, diastase, very similar to the amylase or ptyalin of the saliva in its action upon starch, and at a later stage another enzyme, maltase, contained in the intestinal juice, acts

upon the maltose produced from starch by other enzymes. Lactose and sucrose are split up by other specific enzymes called lactase and sucrase. The products derived from these series of digestive reactions are the various forms of simple sugars such as glucose, galactose and fructose. All three are absorbed but galactose and fructose are converted into glucose by the liver. Glucose is the ultimate product which is utilized by the body.

There remains the conversion of a small part of the cellulose of the food into soluble products. This takes place with the help of bacteria. Cellulose is insoluble and not affected by the digestive juices but it is valuable because when most of the food has been digested it remains solid and when solids are in contact with walls of the intestine its peristaltic movements are increased. Apart from the small amount which is digested by bacteria, it is not a source of energy.

The glucose resulting from digestion of starch and sugars enters into the circulation and passes first through the liver. Some of it is here changed into a substance known as glycogen for storage in the liver, some

remains in the blood and some of the glucose in the blood enters the muscles where it is changed to and stored as muscle glycogen. Glycogen thus stored both in liver and muscle can be changed back into glucose when necessary. Glucose is the chief fuel needed for the release of energy for muscular work and partly for the maintenance of the temperature of the body.

The digestion of fat does not commence in the mouth and usually only small amounts occur in the stomach. Fat is insoluble in water and must be emulsified, that is, the large globules must be split up into small droplets, before it is ready for digestion.

On reaching the small intestine, fat meets the bile secreted by the liver and goes through the process of emulsification because the bile salts have a powerful dispersing effect on substances insoluble in water. It then comes under the influence of a fat-splitting enzyme called lipase found in the pancreatic secretion.

The fats of the food-stuffs are now disintegrated into fatty acids and glycerol, the former are absorbed into the lymphatic system. But before they enter into the blood stream these fatty acids are reconverted into

very fine fat-globules with a large surface compared with their volume. The final stage in the digestion and absorption of fat is reached when these minute fat-droplets in the lymphatics pass into the blood stream. It should be remembered that owing to its insolubility and to the difficulty of mixing fatty substances and water, the fat is not easily digested and that some of it passes through the system without being absorbed and is consequently wasted. Large quantities of fat in the diet depress the digestive processes.

We have seen what an important part bile plays in the digestion of fat. One interesting point about its secretion may be mentioned here: unlike other digestive juices, its formation does not take place at the time of its need. It is stored in the gall-bladder and supplied to the alimentary tract when required.

Fat is stored in the specialized fat-cells in various parts of the body and is drawn upon when food intake is inadequate or during a period of fasting. Fat is particularly deposited under the skin and thereby helps to reduce the loss of heat from the body.

We now come to proteins, the substances which provide building materials for the body

and supply a certain amount of energy. In the last chapter we learnt that the most necessary constituent parts of proteins are amino-acids and here we will try to understand the process of the conversion of proteins into amino-acids.

Now, amino-acids are the final soluble products of protein digestion, a process which is carried out by enzymes in the stomach and small intestine. Through the action of hydrochloric acid and the enzyme called *pepsin*, proteins are split into simpler compounds. On their arrival in the alkaline medium of the intestine, these compounds receive fresh supplies of secretions containing the enzymes called trypsin and erepsin which complete the splitting process. The former is derived from the secretion of the pancreas and the latter from that of the small intestine. The primary value of the action of pepsin lies in turning proteins into a soluble form for their final conversion to amino-acids, which is completed in the intestine.

The amino-acids are then ready for absorption by the cells lining the small intestine. As they enter into the circulation, the tissues of various parts of the body pick out those

which are required for the building up of new tissue protein and the rest is taken care of by the liver cells. Within the liver cells the amino-acids are broken up and their amino groups which contain nitrogen combine with hydrogen. The nitrogen of the amino group is converted into urea which is excreted in the urine along with other waste products. The balance of the amino-acid molecule left over after the nitrogen is removed is either converted into sugar to provide heat and energy later in the general process of oxidation, or converted into glycogen which is stored; or like all the glucose of the body, it may be converted into fat and stored in this form. Hence protein is also a source of the other food constituents such as carbohydrate and fat.

It may now be asked what happens to three other essential food constituents, namely, inorganic substances, vitamins and water, in the process of digestion and absorption. The fact is, none of these needs to be digested, as they can be absorbed unchanged. Their true function is related to *regulating* processes of the body. They play an important role in the activity of various organs and supply essential elements in various body-fluids.

ELIMINATION OF WASTE PRODUCTS

The regular elimination of undigested food residues and of waste products which are set free by tissues and organs in the process of metabolism, is of great importance for maintaining the mechanism of the body in a healthy condition. There are three ways in which unwanted or injurious substances may be removed from the body.

First, by defaecation which means the evacuation or removal of that small part of the food which remains insoluble and, unaffected by enzyme action, passes straight through the alimentary tract. It has therefore never been actually in the tissues of the body, but nevertheless can be extremely troublesome if not properly and regularly eliminated. The bulk of indigestible matter is stored for from twelve to twenty-four hours normally in the large intestine where it is subject to changes resulting in the formation of a poisonous substance caused by ever-increasing colonies of micro-organisms. Their multiplication and the consequent increase in the production of toxins may be affected by the quality and quantity of the diet. Peristaltic movement, which is responsible for evacuation, is initiated by the stretching of the muscles of the wall of

the canal which must be able to grip the contents. For vigorous peristalsis it is therefore necessary that our diet should contain a fair amount of 'roughage', that is, solid food which cannot be digested; and since cellulose cannot be digested by human beings, a diet containing leafy vegetables, fruits, whole wheat, etc., meets this demand. We should bear in mind that constipation is the root of many ills and that it can be avoided by the regulation of diet and meals.

As we have seen, in addition to undigested food, the faeces contain certain other materials for which the body has no further use. These include iron, calcium and magnesium salts and other insoluble materials which are excreted through the walls of the large intestine.

The second method of excretion is by the lungs. The combustion of carbohydrates and fats to provide energy also produces carbon dioxide and water both of which can be given off in the form of gases. Every breath we give out contains 4·4 per cent CO_2 and is saturated with water vapour excreted by the lungs; in fact so urgent is the need for eliminating CO_2 that our rate of breathing is determined by the amount of CO_2 in the blood

and not, as is commonly thought, by the body's demand for oxygen. Some other substances which the body wants to remove and which are easily converted into gases are evacuated by the lungs.

The third method of excretion is used for dealing with those substances which may be excreted in solution. The organs concerned are the kidneys, bladder and the sweat glands of the skin. They remove from the blood and expel from the body nitrogenous products of protein metabolism, such as uric acid and urea, and also excess mineral salts—thus preserving the appropriate slight alkalinity of the blood and tissues which is essential for the healthy life of the cells. Here again, as has been shown, diet can play an important part by the selection of those foods which do not produce too much acid or alkali.

In the table on page 75, the inter-relationship of the various digestive factors is summed up.

Now that we have learnt something of the structure and workings of the body and of the nature of our food, we are able to get a clear idea of what nutrition is. It does not mean food or just satisfaction of hunger. Sir Robert McCarrison gives us a simple

• ILLUSTRATING THE INTER-RELATIONSHIP OF THE VARIOUS DIGESTIVE FACTORS[1]

Food substances	Where digestion takes place	Secretions assisting digestion	Enzymes assisting digestive process	Form in which food substances are utilized	End-products of metabolism
Carbohydrates	Mouth, stomach, small intestine	Saliva Pancreatic and intestinal secretions	Amylase Sucrase Maltase Lactase	Glucose	CO_2 and H_2O
Fats ..	Small intestine	Intestinal secretion Pancreatic juice, bile	Lipase	Fatty acids and glycerol	CO_2 and H_2O
Proteins ..	Stomach, small intestine	Gastric, pancreatic and intestinal secretions	Pepsin Trypsin Erepsin Rennin	Amino-acids	Nitrogenous compounds, sulphur, phosphorus and H_2O
Inorganic salts, vitamins, water	Unchanged during the process of digestion.				

[1] .Composed from Dr M. A. Bridges' *Dietetics for Clinician*, (Kimpton), 1935.

definition: 'Nutrition is the *sum* of the processes by which the body is nourished.' We must lay stress upon the words 'sum' and 'nourished'. All the processes we have described must go on without disturbance and all the substances required for the purposes of regulating these processes must be supplied to the body in order to obtain this *sum*. Only when we obtain this sum, is the body properly nourished. If in any way the processes of nutrition are interfered with, the body cannot get the nourishment from the food. Thus, physical exercise, deep breathing, sufficient sleep, healthy habits and a cheerful mind are factors of great assistance to proper nutrition.

But our purpose here is to find answers to the question, 'what to eat and why'. To enable us to choose the right kind of food, we should know something about the close relation between nutrition and health.

Chapter V

NUTRITION AND HEALTH

Let us summarize what we have so far learnt about the body in its relation to food. The body is likened to something like a stove in which food goes through a process of combustion and produces both heat and energy. We have seen the various processes by which food is digested and absorbed, and how the final products of metabolism are utilized by the body.

We may therefore define food as any material which, when taken into the body, is digested and assimilated and furnishes energy either in the form of movement or heat, and promotes its growth and function. The substances required for the repair of tissue wasted by the wear and tear of the body are derived from food. The body cells are constantly being destroyed and renewed; and the renewal is brought about by rebuilding processes made possible by substances supplied through food. Thus in the broadest sense food includes everything except oxygen required by the body.

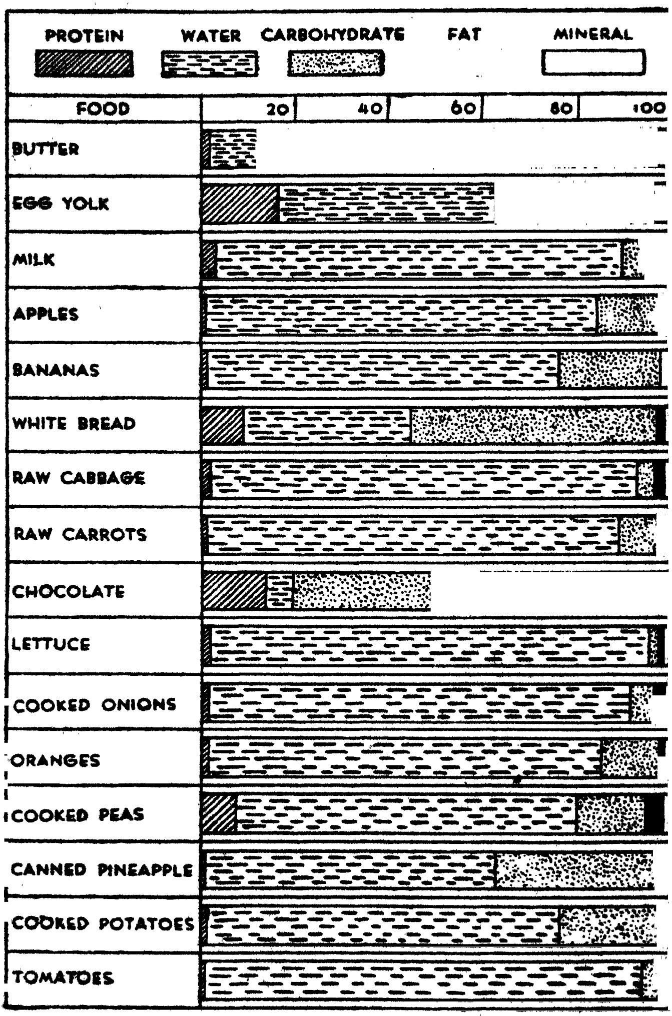
Hunger is the call of the body for solid nourishment and thirst is the need for water. The sensation of hunger depends generally upon nerve impulses arising from the gastric muscular layers when they contract on an empty stomach. The state of the nervous system and body (that is, physiological factors) and also the state of the mind (that is, psychological factors) considerably influence the hunger-sensation by affecting the contraction of the stomach. Carlson [1] in his study of this phenomenon has demonstrated that as the stomach becomes empty, the muscular walls contract from ten to twenty-five or more times, after which there is a rest period. Following this, the contractions occur again and the cycle is repeated with increasing vigour of contraction as more and more time elapses without the taking of food. The accessory phenomena of hunger are weakness, irritability, diminished ability to concentrate and hold attention and diminished muscular efficiency. During a period of prolonged fasting, hunger-sensations and desire for food vanish.

Hunger is usually accompanied by appetite,

[1] Carlson, A. J., *The Control of Hunger in Health and Disease*, (University of Chicago), 1916.

but one may have appetite without hunger. In other words, hunger may be considered as the desire for any food and appetite the relish with which a food is enjoyed. Appetite, as distinguished from hunger, is a psychic factor and is largely influenced by one's state of mind as well as by the attractiveness of the food. Irritation, fatigue, fear, anger, worry, and other emotional disturbances exert more influence in the digestive processes than is usually recognized. Under the influence of strong emotion or excitement not only is the flow of digestive secretions inhibited, but the muscular movements of the entire alimentary tract become depressed. Food consumed under a state of nervous tension puts a strain upon the organism and may result in indigestion.

Any shortage of the essential food constituents we have described in Chapter III makes a difference in our health and well-being. It particularly affects infants and children because they need all the nutrients in proper quantity for the growth and development of the body. We quote here two experiments the results of which demonstrate what difference milk makes in meeting the nutritional needs of children of school age.



Percentage composition of foods in certain articles of diet.

A British medical officer in London undertook to investigate whether there was any deficiency in the usual diet provided by a famous orphanage to its inmates. Although the diet consisted of *good, plain, wholesome food,* their physical development was not satisfactory. A number of healthy children between the ages of seven and eleven were selected for experiment and were divided into six groups. Each group received some particular food-stuff in addition to the ordinary diet which all the groups received. Records were kept of the height and weight of the children of each group and of those receiving only the ordinary diet without a supplement. The supplements given and the increases in height and weight which occurred are shown in the table on page 82.

The results of this experiment furnished the most convincing evidence of the value of milk which made a pronounced difference in the health and physique of the group receiving an extra pint. The boys belonging to this group 'showed the most rapid increases in height and weight and were relatively free from minor ailments, fairly common among the other boys. They were high-spirited and mischievous, and in general showed greater

EFFECTS OF ADDITION OF EXTRA MILK ON GROWTH OF SCHOOL CHILDREN

Group	Extra food supplied	AVERAGE GAIN PER BOY IN ONE YEAR	
		Height (inches)	Weight (pounds)
	Ordinary diet of the Institution (control)	1·84	3·85
1	" " +casein	1·76	4·01
2	" " +sugar	1·94	4·93
3	" " +vegetable margarine	1·83	5·21
4	" " +watercress	1·70	5·42
5	" " +butter	2·22	6·30
6	" " +milk	2·63	6·98

energy and vitality than the other boys'.[1] The next group, which showed almost equally satisfactory results, received extra butter, and it is interesting to note the benefit of extra watercress.

A somewhat similar experiment was recently conducted in Simla by the municipality. Whole milk, pasteurized and bottled, was given to four groups of school children for a

[1] Aykroyd, W. R., *Human Nutrition and Diet*, (Butterworth), 1937.

period of three months, and the result was as follows:

EFFECT OF A SUPPLEMENT OF WHOLE MILK ON A GROUP OF SCHOOL CHILDREN UNDER THE MUNICIPALITY OF SIMLA

AVERAGE GAIN IN THREE MONTHS

	On milk	Control
Boys: Weight (lb) ..	3·84	1·6
Height (in.) ..	0·67	0·49
Girls: Weight (lb) ..	4·54	0·92
Height (in.) ..	0·41	0·06

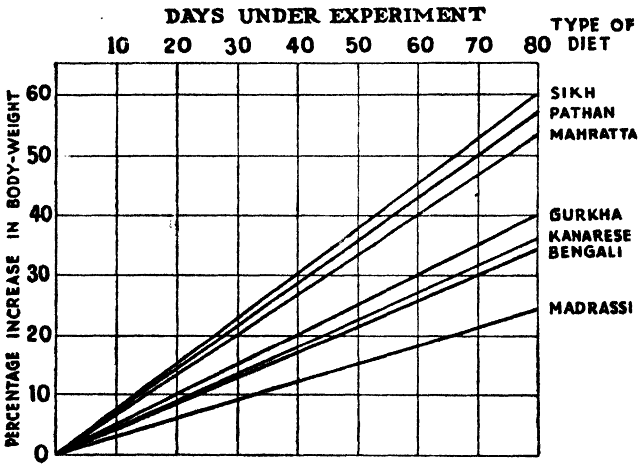
Similar instances could be multiplied in order to show what happens to the body if the diet lacks any of the essential food constituents; or if the body is unable to absorb or make proper use of foods. We must remember that 'food is the instrument of nourishment and nutrition is the act of using it'. In recent years scientific investigators have been able to determine the nature and extent of the relation between deficient diet and diseases; but the fact that a close relation existed and that restricted diets almost

invariably reduced the power of resistance of the body to all sorts of diseases, was common human experience.

Further, diet is an important factor in determining the position of a race in the scale of mankind. There is, for example, a striking physical contrast between the people of Northern India, for example Sikhs and Pathans, and the Bengalis and Madrasis living in the East and South of India. A study of the dietary habits of each of these races shows how great is the influence of diet on physique and health. The Sikhs are tall, broad-shouldered and stalwart. The Sikh diet is mixed and well-balanced. The Hunza is another stalwart and healthy race in Northern India. Their diet consists of wheat, legumes, vegetables, milk and fruits. Although they have no bias against meat, it is eaten only on special occasions.

The people of Bengal and South India are usually short and more poorly developed. Their diet is alarmingly deficient in good proteins, inorganic substances and vitamins. Rice, which is their staple food, is largely milled; the amount of vegetables, fruits and milk usually consumed is inadequate; and it is now recognized that one of the fundamental

causes of poor physique, widespread ill-health and disablement of the peoples living in the East and South of India is their low and deficient dietary standards.



The diagram shows the rate of growth of groups of rats which were fed on the various national diets of India. The development of the animals corresponds with that of the human beings who use the same diets.

The experiment was carried out by Sir Robert McCarrison.

Health may be disturbed by several types of nutritional disorder. Food-stuffs containing essential nutrients may be absent or present in smaller amounts than is necessary for the body. Or the capacity to digest and metabolize foods may be another reason for

nutritional deficiency. Again, in the process of cooking and preparation, there may be a considerable loss of nutritive substances. The symptoms of ill-health or of pronounced physical ailments, caused by inadequacy or lack of essential nutrients, are known as 'nutritional deficiency diseases'.

A form of paralysis of muscle, usually of the lower limbs, accompanied by pains, is associated with the consumption of a diet consisting largely of over-milled cereals. It is called *beriberi*. It is due to lack of vitamin B_1 which is removed from the grain by the milling process. *Scurvy* is another disease of dietetic origin: it is found to be due to the lack of vitamin C. The signs of the disease are swollen and spongy bleeding gums, painful joints, a sallow complexion and anaemia. It was of common occurrence among seafaring people during long voyages because of a lack of *fresh* fruit and vegetables. As early as the thirteenth century, the English physician-monk Gilbert advised sailors to use sun-dried fruits on their voyages. It is now established that scurvy is caused by the deficiency of the water-soluble and unstable vitamin C usually present in fresh fruits and vegetables.

The war of 1914–18 taught us many lessons about food and its relation to health. In Germany and other parts of Central Europe large numbers of the population suffered losses in weight amounting to 15 to 25 per cent of the original body-weight and at the same time there was also an increase in the death-rate from tuberculosis. At the siege of Kut, the Indian soldiers developed scurvy because their diet consisted of very coarsely-ground wheat flour and dried legumes, without any fresh meat or vegetables. There was, however, not a single case of beriberi among them. It broke out in the British army because the diet consisted of white army bread and meat, partly fresh, largely tinned, with very little fresh vegetables. In Belgium, the peasants were forced to sell their entire output of dairy produce and fresh vegetables. The absence of these foods in the dietaries of the peasants produced a peculiar eye defect known as night blindness. When they were given foods rich in vitamin A, their eye troubles disappeared.

Vitamin A, a fat-soluble vitamin, is essential to the growth and development of the young and helps the body to maintain its resistance to infection. It appears to exercise a special

protective influence upon eyes, skin, and the mucous membranes of the mouth, and of the respiratory tracts. Its deficiency is common in India and therefore night blindness and other eye diseases, skin diseases, sore-mouth and tongue and similar symptoms of the effects of vitamin A deficiency are so widespread among our people. Diets poor in good fats are associated with rickets.

Pellagra, a kind of eruption on the skin, breaks out among those whose diet is habitually deficient in vitamin B_2. This disease is found in almost every country in the world, but it is common among the peoples living in poverty. The study of this disease has shown that many skin troubles are caused by diets in which there is not enough vitamin B_2. A dry, withered skin as we frequently see in the poor class of people in India is an indication of the lack of this essential food constituent.

Defects in bone formation, such as rickets, are known to be caused by the lack of vitamin D and can be cured by the use of the foods containing this substance. Then there are those inorganic substances we mentioned in Chapter III the lack of which produces a

number of diseases. Tooth decay and most of our dental troubles are due to an inadequate supply of calcium and vitamin D. If we do not have enough iron in the blood stream we suffer from anaemia, that is, the haemoglobin (red corpuscles) becomes pale and we look sickly. It can be cured by the use of food-stuffs containing calcium, iron and vitamins.

We may not actually suffer from these specific diseases mentioned here but that does not necessarily prove that our diets are well supplied with all the essential nutrients; or that they are normally absorbed and assimilated by the body. Our resistance to infection may be weakened by the continued use of a faulty diet and although we may be getting enough food we may still be suffering from malnutrition. That is why Sir Robert McCarrison points out that malnutrition is not itself a state of ill-health so much as the cause of many states of ill-health. For example, marked deficiency of good protein in the diet over a considerable period reduces the supply of the building material for the body and undermines its resistance to infection. The poor physique of the peoples of Bengal and Madras is due largely to their low-protein diet.

We have cited enough instances to show that faulty or inadequate diet is responsible for more ill-health than any other single cause. If we look around us, we will find that a very large proportion of our population is undernourished and that faulty diet is largely the cause of the lack of mental and physical energy of the individual.

The relation of food to disease or ill-health may now be summed up as follows:

1. Error in quantity, that is, we may not have enough to supply the energy requirements of the body or provide for body growth or maintenance. (See Chapter VII.)
2. Error in quality; that is, there may be an inadequate intake of separate necessary food constituents, such as vitamins and inorganic substances.
3. Disturbances in the processes of digestion, assimilation of food and elimination of waste products.
4. Food adulteration.
5. Infection through food-stuffs.

We should now learn something about food hygiene. Sweets and other foods from the dealer, exposed as they usually are to dust, insects, and flies, are liable to contamination with disease germs. Both the feet and the excrement of flies are sources of contamination and it is known that typhoid fever, cholera, dysentery and other infectious diseases spread

largely through fly pollution. Food poisoning is also the result of microbic infection and could be avoided if sufficient care is taken in the preparation of the food. Vegetables, fresh fruits, dry fruits and other food-stuffs should be carefully washed. Bruised fruits and vegetables should not be eaten raw. The eggs of certain parasitic worms, for example tapeworms, may be introduced into the body if food-stuffs are not properly cleaned.

We have also to guard ourselves against the traffic in adulterated food-stuffs, such as milk, ghee, butter, oil and atta. There are a number of pure food legislations to control the evil practice of adulteration in India, but they will not be properly and adequately enforced until the public becomes educated as to the grave consequences of consuming impure foods.

Before we turn to our next lesson where we learn something about common food-stuffs, we should know how the food substances essential for health and growth are now classified into two groups. This classification is based upon the knowledge of the functions of these food substances in maintaining our body in health. One group of food-stuffs is called 'energy-bearing' and the other

'protective'. Since carbohydrates supply energy, the food-stuffs from which they are obtained are energy-bearing foods. Cereals, cakes, biscuits, and sugar belong to this group. The inorganic substances and vitamins do not yield energy but if our diet is deficient in them, poor physical development and certain forms of ill-health result. Therefore milk, butter, cream, eggs (especially the yolk), fresh, green vegetables and fruits are protective foods because they are rich in these substances. It is the discovery of the relationship of these protective foods and normal health that has aroused so much interest in the need for the proper use and choice of foods. While both these groups of food-stuffs are necessary for proper nourishment, the increase of the proportion of protective foods is important and desirable.

Chapter VI

OUR COMMON FOOD-STUFFS

We will now consider some of our common food-stuffs in order to acquaint ourselves with their dietary values. With the exception of salt, all our foods may be classified into two groups, namely, those of plant origin and those that are derived from animal sources. In the last analysis, however, it is the plant world which sustains us all; for the animals from whom we obtain food depend for their sustenance upon plant foods. Thus all the elements of nutrition come *primarily* from the vegetable kingdom.

In all countries the basic industry is agriculture and the primary business of agriculture is to nourish the population. Food habits of peoples depend chiefly upon the abundance of the foods available to them in the areas they inhabit. In the coldest part of the earth mankind subsists largely upon a meat diet. The Eskimos, for example, live upon birds, seals and other animals. The inhabitants of the warmest regions are generally vegetarians and live upon rice and

varieties of edible vegetables and grains. There is a scarcity of milk and milk-products in these areas. In the dryest regions (for example the Sahara and Arabian deserts) human food is obtained by raising cattle and flocks of sheep and goats in extensive pasturage.

Today because of the increasing facilities for transport and for food-preserving industries food supplies in one part of the world need not however be restricted to any geographical environment. By the application of science to agriculture it has been possible to increase food production but the organization for distribution of food is not sufficiently advanced to wipe out food shortage in the midst of plenty.

We now proceed to study some of our familiar food-stuffs. Data regarding their nutritive values are now being accumulated by the Nutrition Research Laboratory at Coonoor (South India), and the All-India Hygiene Institute in Calcutta. With the help of these and other sources of information, we are able to estimate the food values of our ordinary food-stuffs. A classification of these data is given in Appendix B.

Foods of plant origin may be broadly classified as follows:—

1. CEREALS: wheat, millet, rice, barley.
2. PULSES: gram, peas, beans, lentils, soya bean, etc.
3. VEGETABLES: potatoes, onions, cabbages, cauliflowers, green peas, beans, gourds, cucumbers, drumsticks, etc.
4. FRUITS: bananas, oranges, pomeloes, mangoes, melons, plums, papayas, apples, dates, raisins, figs, nuts, etc.
5. OILSEEDS: mustard, groundnut, sesame.
6. SUGAR: cane sugar, gur, jaggery, honey.

We will take up each of these groups for a brief discussion of its importance in human dietaries.

CEREALS

Of all food-stuffs the cereals should be given our first consideration as they are the 'backbone of nutrition of most of the races of the earth'. The name is derived from Ceres, the ancient Greek goddess of the grains and the harvest.

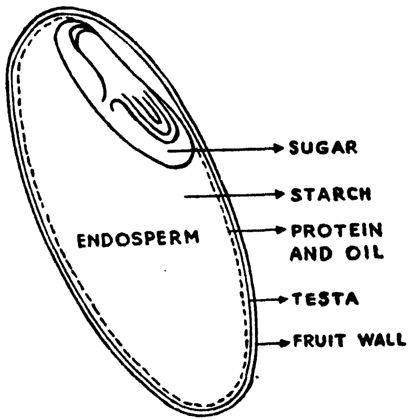
Wheat, millet, rice, barley, oats and maize are the main cereal grains which supply carbohydrates. These are therefore classified as energy-bearing food-stuffs, and constitute

mankind's chief means of subsistence. They are easily grown and may be stored and transported with facility; they furnish an abundance of carbohydrates very cheaply, and are easily prepared for consumption—all these factors combine to place cereals in the category of the staple food of all races.

Any process of refinement in the manufacture of cereals, such as milling and polishing which removes the germ and outer layer of the grains, lessens, to a great extent, their nutritive value. After milling, the proteins in the grain are likely to be inadequate or incomplete. Fat is present mostly in the germ or embryo. The inorganic substances vary widely with the different cereals. As regards vitamins, cereals are usually deficient in vitamins A, C and D, but when unmilled contain generous amounts of vitamin B_1, the absence of which, we have seen, results in beriberi and similar nervous complaints. In any case, cereals are not complete foods and should be supplemented with such foodstuffs as make up their deficiencies. The use of cereals without an adequate supply of protein, fat, vitamins and inorganic substances leads to malnutrition.

(*a*) *Wheat*

This is one of man's most ancient and highly prized cereals. The Chinese call it the 'gift of Heaven'. In the ancient Egyptian Pyramids there are carvings showing wheat kernels being ground between stones. The scientific name for wheat is *triticum vulgare* from the Latin verb *tritere* which means to thresh or grind. The wheat kernel consists of three main parts, namely, the bran, the endosperm and the germ or embryo. The tough protective covering is the bran consisting mainly of cellulose and it is richer in inorganic constituents than any other part of the kernel. The endosperm contains the substances called gluten (protein) and starch, and the germ contains protein which is unlike gluten, vitamins and inorganic constituents.



Section of wheat grain.

Wheat supplies more and better protein than rice.

The device used for grinding wheat kernels into flour in India is somewhat like the quern of the Greeks and Romans. The flour (*atta*) obtained from the *chakki* is more nutritious than that produced by roller mills. There is no reason why the consumption of this wholesome food should not be increased in India as the cultivation of wheat in India can be extended. It is chiefly grown in Northern India as far east as the Gangetic delta.

For the purpose of baking bread, the chemical composition of flour is of the utmost importance, particularly the protein content which is regarded as its 'strength'. But we make *chapatis* and therefore our requirements, in regard to the milling and baking qualities of wheat, are different from those of the baker. The varieties of wheat suitable for *chapatis* should contain a high percentage of starch and less gluten.

Macaroni, spaghetti, vermicelli and semolina are some of the food products prepared from varieties of hard wheat with a high gluten content. Rolled, puffed, shredded and similarly prepared wheat products are now largely

used in the dietaries of the western countries. In India varieties of wheat are used in the preparation of sweets like *halwa*, *payasa* with *suji* (cream of wheat) cooked with butter, milk and sugar.

(*b*) *Millet*

Millet is one of the cereals known to have been cultivated since prehistoric times in tropical and semi-tropical zones. The term millet includes several species of allied cereal grains. In nutritive value this cereal ranks next to wheat. Its protein content is low, but the essential amino-acid lysine is high. Millet is a rich source of vitamin B_1.

Defects in a millet diet can be corrected by supplementing it, as is the case with all cereals, with *ghee*, vegetables and various kinds of lentils. Since millet is poor in certain inorganic constituents such as calcium and iron, a liberal use of green vegetables would, to a great extent, make up the deficiency.

In areas where millet is grown, it is largely consumed by the poorer groups of the population. There is a common saying among the peasantry in the United Provinces: 'Juar is my mother and makes my cheeks

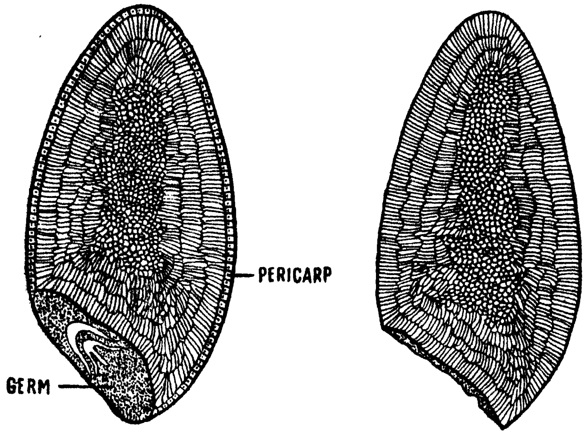
glow with health; bajra is my brother and helps me when I am weak.'

(c) *Rice*

It is estimated that about a third of the world population depends on rice for sustenance, but it is not a high grade cereal. Its nutritive value is considerably less than that of wheat. The average grade of rice has the highest percentage of starch but it is poorest in proteins, inorganic substances and vitamins. In India it is the staple food of the population in Bengal, Bihar, Orissa, Assam, Madras, Bombay and Burma. There are several varieties of rice ranging from fine flavoured *basmati*, *dadkhani* to plump and coarse grains such as *aus*, *nagri*, etc.

Of all cereal grains rice is low in nutritive value and it is rendered even poorer by milling and polishing. Unfortunately the consumption of polished rice is increasing in India. We have seen that the occurrence of beriberi is so common among those who are in the habit of consuming highly milled and polished rice because such treatment removes over fifty per cent of the inorganic substances and nearly all the vitamin B_1 content. The food value of rice is thus greatly reduced by

the milling process. The use of home-pounded and unpolished rice should therefore



Unmilled grain: germ and outer layers complete.

Milled grain: germ and outer layers removed.

Rice grains.

be encouraged among the rice-eating peoples of India.

The nutritive deficiency of rice can be made up to a certain extent by the addition of milk, butter, curd, pulses, fish and green vegetables.

The people of India consume various forms of prepared rice such as *chira* (steamed and rolled), *muri* (puffed), *koi* (toasted). They all maintain an important role in the dietary of the country, and they are palatable and

nutritious. Rice flour and rice starch are used in the preparation of sweets.

(*d*) *Barley*

Some historians regard barley as the most ancient food of mankind. With the discovery of its value as a good source of malt in the brewing of beer, it has been replaced by other cereals as an important bread-stuff. Barley does not however contain sufficient gluten to make good bread. It does not appear to differ substantially from wheat and rice in its carbohydrate content; but barleys of good variety are comparatively rich in inorganic constituents. The Japanese consume a considerable quantity of barley in various forms. Barley flour is used as invalid and baby food. In India by far the largest quantity of this crop is grown in the North-West Frontier Province and the Punjab.

There are other sources of starchy food such as sago and tapioca. Sago is prepared from the pith of a tropical palm and is a food of high energy value. It is easily digested.

PULSES

Chief among the varieties of pulse

commonly used in India are grams, peas, beans, lentils and vetch. These are the seeds of a group of plants known as legumes which have the property of utilizing the nitrogen of the atmosphere and thus building up their protein content. Leguminous seeds are therefore valuable as human foods. These seeds must be washed and cooked thoroughly, especially if the diets are of vegetarian character. Legumes are usually rich in carbohydrates but poor in the amount of fat. Some of them have a relatively high protein content but these proteins lack certain essential amino-acids. The protein of peas, beans and lentils is therefore incomplete; that is, it is of inferior value to that of milk, eggs or fish. The Soya bean is one of the legumes which contains good proteins. The vitamin content also varies according to the kind of legume. Germinated legumes are rich sources of vitamin C.

VEGETABLES

A considerable portion of our diet is obtained from a great variety of vegetables. Some are eaten raw, while others require to be cooked singly or in combination with other food materials. The discovery that

vegetables were good sources of vitamins and inorganic substances has greatly enhanced their 'power and prestige' in the human dietary. In the western countries there has been a great increase in the consumption of tomatoes, cucumbers, lettuce, celery, etc., within the last ten years.

The chief benefit derived from the consumption of green leafy vegetables, such as tomatoes, celery, and cucumbers, is the supply of essential vitamins and inorganic substances.

There are several methods of classification of vegetables, but for our purpose it is perhaps convenient to group them with reference to those parts of plants generally used for human food, namely,

1. Bulbs, tubers, roots, e.g. onions, potatoes, sweet potatoes, carrots, radishes.
2. Leafy and flower vegetables, e.g. spinach, watercress, cabbage, cauliflower.
3. Fruit vegetables, e.g. peas, beans, cucumbers, pumpkin, squash, tomatoes, brinjal, gourd, *bhindi*.

1. *Bulbs, tubers, roots.* Under this group potato is the most important food crop. It furnishes an excellent form of starch which decreases in storage. Food experts consider that 'potatoes are also a valuable source of

iron and vitamin C, and are of particular value, because they retain a high percentage of their vitamin C content after cooking'. The protein is not of inferior rank. Onions and garlic are fairly rich in vitamin C. Carrot is a nutritious root vegetable, rich in vitamin C and inorganic substances such as calcium.

2. *Leafy and flower vegetables.* Green leafy vegetables are regarded as an essential part of a good diet because they are rich in vitamins and inorganic substances. They do not furnish a large quantity of protein but the small amount contained in them is of value. The varieties of spinach, tops of radish and beetroot, watercress and similar leafy vegetables are extremely desirable food supplements for raising the nutritive level of a predominantly cereal diet. The Spartans ate watercress with their bread. The Chinese favour abundant green leafy vegetables in combination with rice, especially if their diet is deficient in milk and milk products. Cauliflower is perhaps the most common of all flower vegetables and is becoming increasingly popular among our urban population; but cabbage is perhaps the most valuable of all leafy vegetables.

3. *Fruit vegetables.* Of the fruit vegetables,

fresh tomatoes, cucumber, various kinds of gourd, and large peppers contain a fair amount of vitamin C. Pumpkins, squash, vegetable marrow are not nutritious but they provide a cheap source of bulky vegetable.

FRUITS

The importance of fruits in the human dietaries has been recognized ever since prehistoric times. They are regarded as a vital food and valuable appetizers. From a nutritional standpoint they are valuable chiefly on account of their contents of vitamins and inorganic substances. Fresh fruits vary considerably in composition and even the same fruit may show fairly wide differences under different cultural conditions, the degree of ripeness and the variety grown.

Several kinds of fruits can be grown in India, but unfortunately adequate attention is not given to the recognized scientific methods of their cultivation and transportation. Mangoes, lichis, bananas, melons, oranges, lemons, pomeloes, grapes, papaya, dates and figs are some of the fruits available in the Indian market.

The edible portions of fruit are poor in fat but contain a fair amount of carbohydrates

and proteins, although less than most other food-stuffs. Bananas, figs and varieties of nuts are, however, favoured by strict vegetarians as the chief source of energy which is largely supplied by sugar. During ripening, starch in the unripe fruit is converted into glucose, the form of sugar most readily absorbed by the body. Overripe fruit loses both food value and flavour.

Citrus fruits, figs and pineapples contain a fair amount of calcium while prunes, dates, berries and grapes are good sources of iron. Although acid in taste, the fruit pulp is oxidized to an alkaline residue in the body, owing to the formation of carbonates from the acid salts. Fruits are therefore regarded as being helpful in the maintenance of acid-base equilibrium in the body. The aroma of fruits is derived from aromatic compounds formed by combination with the organic acids and the sugar.

Of the vitamins, fruits usually contain a fair amount of vitamins B and C. The citrus and juicy fruits are by far the best source of vitamin C. With the exception of this vitamin, practically all the food nutrients of fruits remain in the process of dessication and therefore dried fruits are important

sources of nourishment. The fruit may be dried in the sun or dehydrated artificially in evaporators.

Nuts. Nuts of all kinds should be given an important place in our dietary especially if it is mainly vegetarian in character. They furnish carbohydrates, proteins, fat, mineral salts and vitamins; but these vary considerably in different nuts. Almonds, for example, contain over twenty per cent proteins while fresh chestnuts yield about six per cent. The nut proteins are comparable in quality to those of meat and fish.

Coconut is a rich source of vegetable fat and figures largely in domestic cookery in India. The ripe kernel which contains over fifty per cent of organic matter is nutritious. The coconut water is a refreshing drink especially if it is obtained from the young nut. It is given to invalids suffering from gastric troubles because of the presence in it of glucose.

Groundnuts are one of the valuable legumes yielding vegetable oil, but they are also a source of good proteins. The oil is used for cooking. Groundnut flour may be mixed with wheat to make bread and biscuit palatable. Various other edible nuts available

to us are the cashew nut, pistachio nuts and chestnuts. All are highly nutritious.

OILSEEDS

Vegetable oils have long been used for human consumption. The oil is extracted from the seeds by pressure, occasionally with the aid of heat. Certain kinds of these extracted oils have to be refined and the disagreeable flavours removed before they are used for cooking.

There are a number of plants on which we depend for supplies of vegetable oils. Seeds of the mustard (sarson), pea (groundnut, soya bean), flax (linseed), mallow (cotton seed), and the pedalium (sesame) families furnish us with some of the cheap sources of oils used for culinary and other purposes. Mustard yields about twenty to twenty-five per cent and groundnut as much as thirty-seven to fifty per cent oil. Two other sources of vegetable oil are dried coconut kernel and mahua. Mahua oil is used as an adulterant in *ghee*.

SUGARS

Commercial white sugar is obtained from sugar-cane and beet. Beet juice requires

more drastic refining and bleaching than cane sugar, but excessive use of both kinds of white sugar is a serious dietetic blunder. It is one of the causes of dental decay. It is a cheap source of carbohydrate, providing energy, but contains no other nutrients. India is a heavy consumer of sugar, a great bulk of which used to be imported mainly from Java; but in recent years, the cultivation of sugar-cane has greatly extended in India.

The liquid which remains after the crystals are removed in the manufacture of sugar is what we consume as treacle or molasses. It contains all soluble inorganic constituents of the juice not removed during clarification. The use of *gur* should therefore be encouraged.

Honey. It is defined as 'the nectar and saccharine exudations of plants, gathered, modified, and stored by the honey bee'. It is an excellent source of sugar because it is more rapidly absorbed into the blood stream than white sugar and *gur*; this is because it consists of glucose and fructose which require no digestion before absorption. It is not easily fermented. The characteristic odour and flavour of honey is due to certain volatile substances and its colour depends upon the nectars of the various flowers.

We will now consider the foods that are obtained from animal sources. They may be grouped as follows:

1. MILK AND MILK-PRODUCTS: milk, cream, butter, dahi, khoa, cheese.
2. EGGS: duck, hen, turtle, fish.
3. FISH: fresh and sea-water.
4. MEAT: mutton, beef, poultry.

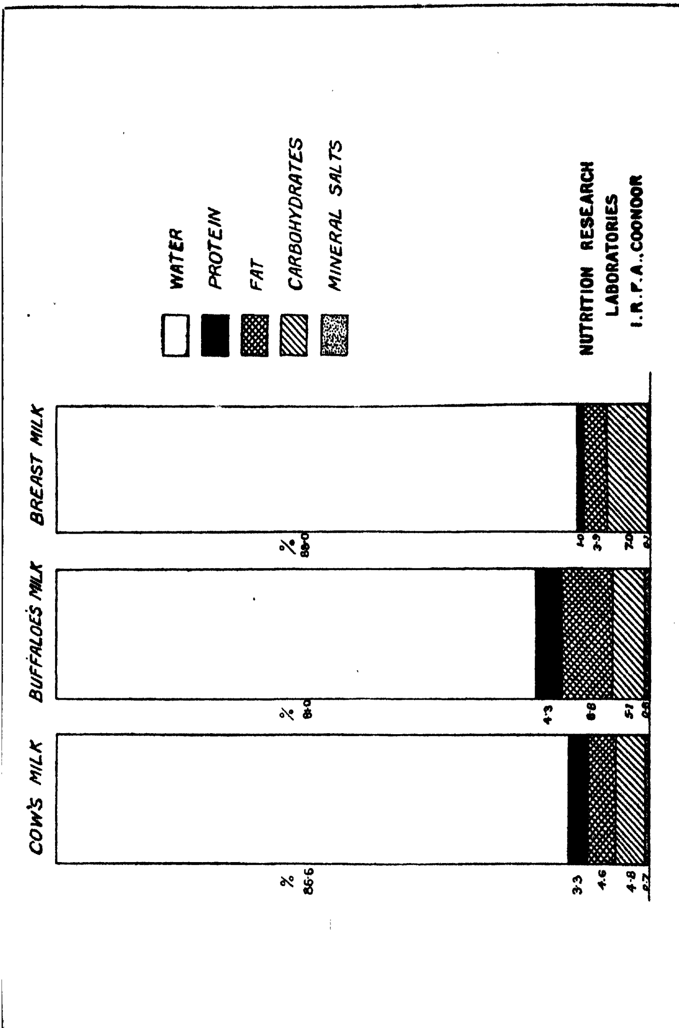
MILK AND MILK PRODUCTS

If we define an ideal food as being one which contains all the materials essential for growth and maintenance of life in a form ready for utilization by the body, then milk is 'the nearest approach we possess to a perfect and complete food, and no other single food is known that can be used as a substitute'.[1] It contains carbohydrates, fats and proteins which are the energy-bearing nutrients and also those essential vitamins and inorganic substances which furnish the body with 'protective' materials. The proteins of milk are of the highest quality and better suited to our needs than those of most other foods are; that is, they furnish all the essential amino-acids. The deficiency of cereal diets is largely corrected by a liberal use of milk. Milk-

[1] *The Problem of Nutrition*, League of Nations Interim Report, 1936.

sugar or lactose is the carbohydrate of milk and it is readily converted into glucose and galactose by digestion. Milk fat consists of a number of compounds of fatty acids already existing in highly emulsified forms, and is therefore one of the most easily digested forms of fat. Of the inorganic food substances, milk is rich in calcium and phosphorus but poor in iron. It has no equal as a natural source of calcium and calcium in milk is better absorbed than that contained in vegetables. Milk is especially rich in vitamins A and D, but its vitamin C content is likely to be destroyed or reduced by boiling.

You will at once see why milk is regarded as the most important of all foods; but the value of milk as an essential food is not a new discovery. The lion cub, the whale, and the tiny kitten depend upon milk for their sustenance in infancy, and so does man. This source of nourishment has been recognized by man since the dawn of civilization, and animals that supplied him with milk were regarded as valuable possessions. Milk and milk products are valuable health foods and they are accorded a welcome place in the dietaries of all classes and communities in


WATER
PROTEIN
FAT
CARBOHYDRATES
MINERAL SALTS
NUTRITION RESEARCH
LABORATORIES
I.R.F.A., COONOOR
COW'S MILK
BUFFALOES MILK
BREAST MILK
%
86·6
3·3
4·6
4·8
81·0
4·3
6·8
5·1
88·0
1·0
3·9
7·0

India; but their supply is inadequate. The milk consumption in India by children from infancy to fourteen years of age is far below the minimum absolutely essential for their satisfactory growth and well-being. Milk is a particularly suitable medium for the growth of micro-organisms and therefore great care is essential for its production, distribution and consumption. The amount of nutrients in milk, such as the vitamins, depends on proper feeding and facilities for the grazing of the cow.

(*a*) *Chana.* This is the coagulated casein of milk. Casein is the most important of all milk proteins and constitutes about eighty per cent of the total in cow's milk. When casein is precipitated by acid, most of the fat of the milk is precipitated at the same time. Casein is a nutritious food and must be used fresh as it deteriorates very quickly. In combination with sugar it forms the basis of several varieties of delectable sweet preparations so common throughout India. Various kinds of soft cheeses are also made from casein. Whey is the liquid which is obtained after precipitation of casein and fat, and its use in digestive disorders is recommended because of its low protein but rich inorganic contents. It is easily assimilated.

(*b*) *Butter.* Cream is obtained by separating the fat of the milk by allowing it to stand while the cream rises or by spinning it rapidly when the light fat particles are separated from the heavier water. When in the process of churning soured milk or ripened cream, the emulsified fatty particles are lumped into semi-solid form, and we get butter. It is one of the richest sources of fat soluble vitamins A and D. Good dairy butter should contain at least eighty per cent of fat and should have a pleasant aromatic odour. Its normal colour should be yellow, but it depends largely upon the quality of fodder. As butter tends to become rancid, it is a common practice to add salt in small amounts. In India butter is prepared from cow's as well as buffalo's milk. The latter is richer in fat. Buttermilk is the product that remains after churning and it contains all the milk constituents except fat. It is a healthy drink. It is known as *chachh* in the United Provinces and *lassi* in the Punjab.

Sour milk. Milk turns sour by the action of certain bacteria which thrive upon milk-sugar and convert it into lactic acid precipitating the casein. It has, owing to the aroma of the lactic acid, a pleasant flavour and that is why the curd is often preferred to milk.

(*d*) *Skimmed milk* is a nourishing drink although it contains practically no fat or vitamins A and D; but other constituents of whole milk remain there. It is one of the important sources of vitamin B complex and is rich in protein and minerals. It is used in some countries in bread making. For the sake of economy in the supply of protein, a kind of cheese is also prepared from skimmed milk. Dried skimmed milk is of great value to children whose regular diet contains no fresh milk or milk products. Its use, fresh or dried, may increase the nutritive value of the diets in which the supply of whole milk is absent or limited.

Lastly, we should mention 'processed' milks, such as condensed, evaporated and dried, which are now available in the Indian market. The water in the milk is evaporated at a low temperature and sugar is added in the process of condensation; the products are then packed in tin cans and there we have condensed milk.

EGGS

The eggs of ducks, fowls, geese and guinea fowl are used in the dietaries of most peoples. Of these different kinds, the hen's egg is the

most popular, and it is an almost indispensable food in the western countries. By the application of science to poultry farming, the size and production of eggs have been considerably increased.

Eggs do not contain carbohydrates but are an excellent source of proteins, the most important of which is ovalbumin found in the gelatinous material known as the egg white. The yolk is rich in fat, contains a protein called vitellin, and also has a fair amount of fat-soluble vitamins A and D. Vitamin B complex is present in small amounts. The yolk varies in colour from a pale yellow to deep orange, depending probably on the feed of the hen.

One of the possible reasons why eggs are not popular in the tropics may be due to the fact that they deteriorate rapidly in a warm atmosphere. In all egg-consuming countries, great care is taken in storage and transportation at a low temperature.

Fish

There are many types of fish used as edible foods and among non-vegetarians they are popular. Fish is a source of good protein and fat and is more easily digested than

meat. There is a considerable variation in the fat content of numerous kinds of fish we eat. Its flavour is probably influenced by the amount of fat and also by the water in which the fish lives. Fish oils contain vitamins A and D. Shell-fish are rich in minerals but rather poor in fat content. The salt water fish are valuable as a source of iodine. Fish livers, as already mentioned, are especially rich in all the fat-soluble vitamins, except vitamin E.

MEAT

The flesh or muscles of all animals available for human consumption is meat. Its nutritive value is primarily due to protein and fat, but it is not an indispensable food. Almost all meat available in India is of a poor quality. Goats' flesh or mutton is prized by non-vegetarians because of its fat which supplies a fair amount of vitamin A. The deficiencies of a high cereal diet are made up to a great extent by the use of meat, but it is of utmost importance that the animals from which it is obtained for human consumption are free from disease at the time of slaughter. The nutritive value of meat varies within wide limits in accordance with the kind of animal,

age, health and breeding. Poultry furnish a palatable source of good protein and may probably be regarded as the most easily digested meat. The digestibility of meat, however, depends greatly upon the manner of cooking. Those who are accustomed to eating meat in a hot climate should only do so in small amounts.

From this brief account of the common food-stuffs we may form a correct estimate of their food values. The knowledge thus gained is helpful to us in balancing the nutrients in our diet; for the complete absence, or inadequate supply of a single food constituent or excess of one at the expense of the other, is injurious to our health. In the nutritional charts given in Appendix A you will find a summary of what we have so far learnt. You may now ask how much of these food constituents should we have in a diet in order to make it balanced. In the next chapter we shall proceed to find an answer to this question.

Chapter VII

THE BASIS OF DIETARY STANDARDS

In our study of the living body we have learnt that every moment it uses energy. Whether we sleep or sit still there is no cessation of muscular activity in the body. When we work or play the activity increases, and with it the expenditure of energy.

This energy has to be provided by food, and we have already discussed how the body transforms the energy value of food. If its supply is inadequate, the body has to burn its own substances as fuel to meet the deficit. Thus, when a working man spends more energy than his daily bread yields him, he is undernourished.

How are we to measure the energy requirement of the body? The unit of measurement scientists have adopted is known as the calorie.[1] One unit represents the amount of

[1] In nutritional work the unit of heat used is the large calorie which is the amount of heat required to raise a litre of water through 1°C. It is therefore one thousand times greater than the small calorie used in physics.

heat which will raise the temperature of one pound of water 4°F. It is found that carbohydrates and proteins yield 4·1 calories for every gramme burned and fats yield 9·3 calories. An example may be given here to illustrate how calories are worked out to determine the measure of food value.

Let us say, one ounce of milk contains

Protein ..	..	·94 gramme
Fats ..	..	1·13 ,,
Carbohydrates	..	1·41 ,,

One pint (i.e. sixteen ounces) of milk would therefore furnish

Calories from protein ..	$0{\cdot}94 \times 16 \times 4 =$	60·16
Calories from fats ..	$1{\cdot}13 \times 16 \times 9 =$	162·72
Calories from carbohydrates	$1{\cdot}41 \times 16 \times 4 =$	90·24
	Total ..	313·12 Calories

Or let us take another example. You put a lump of sugar weighing half an ounce (i.e. about 15 grammes) in your milk. If you wish to calculate the amount of calories sugar supplies, you proceed thus:

Since sugar contains nothing but carbohydrate, it gives you $4 \times 15 = 60$ calories.

The apparatus which measures the energy released in the body by the essential food constituents such as carbohydrates, fats and proteins is called the calorimeter.[1] It consists of a chamber suitable for accommodating the animal which is to be studied, surrounded by water coils and other contrivances containing thermometers so that heat produced by the body may be measured. The apparatus also has a device by which the amounts of oxygen used and carbon dioxide produced by the animal may be measured. Calorimeters large enough to contain a human being have been constructed and many important results have been obtained from their use.

All foods, except water, salts and vitamins, yield some calories. Foods vary in energy value because their chemical compositions differ, and from them we can ascertain fairly accurately how much of each nutrient (i.e. carbohydrates, proteins and fats) is required for the maintenance of health. The science of nutrition has now reached the stage of development which enables us to estimate the energy requirements of the body. The minimum rate of energy used by a normal person when

[1] Calorimeter: calor—heat, meter—measurement.

awake but lying still twelve hours after his last meal is called 'basal metabolic rate'. That is the amount of energy required to maintain the basic functions such as heart-beats and breathing. Thus, the basal metabolism of an individual can be determined with a high degree of accuracy by using the calorimeter.

Energy requirements of the body depend on activity, age, size, body-weight, environment, hygienic habits and sex. Of these the most variable single factor which determines the rate of energy expenditure is muscular activity. When one is active, the muscles require much food and oxygen. A statement issued by an expert Commission of the League of Nations [1] upon the subject of energy requirements may be quoted here:

> A. An adult, male or female, living an ordinary everyday life in a temperate climate, and not engaged in manual work is taken as the basis on which the needs of other age-groups are reckoned. An allowance of 2,400 calories net (i.e. the total amount of energy available from the food actually assimilated) per day is considered adequate to meet the requirements of such an individual.

[1] *Report on the Physiological Basis of Nutrition*, League of Nations, 1936.

B. The following supplements for muscular activity should be added to the basic requirements in A.

Light work: up to 75 calories per hour of work.

Moderate work: up to 75–150 calories per hour of work.

Hard work: up to 150–300 calories per hour of work.

Very hard work: up to 300 calories and upwards per hour of work.

For practical purposes, under the conditions of life in the western countries, the requirements of an adult man engaged in moderate work are estimated at 3,000 to 3,400 calories, and of a woman at 2,600 to 2,800 calories. For children the standard varies according to age from 30 per cent of the adult standard at the age of one to two years, rising to the full adult requirements at the age of fourteen. This may appear strange but the total metabolism of healthy children of fourteen years, owing to their almost incessant muscular activity, often exceeds that of adults. Consequently their food consumption is proportionately great.

But in India where climatic conditions, nature of occupation and social habits differ, this standard may be justifiably reduced. We live in a tropical and sub-tropical country; our occupation does not generally involve heavy manual work as that of highly in-

dustrialized countries; and our diet is largely vegetarian. If we are to set up dietary standards approximating to the *needs* of our divergent races and communities who, living under different geographical environment, have taken to varied dietaries, it is necessary that a well-planned investigation into the problems of nutrition should be undertaken throughout India. Meanwhile, the calorie requirements of our people of different age and sex groups have been estimated by W. R. Aykroyd [1] as follows:

SCALE OF AVERAGE CALORIE REQUIREMENTS

Adult male (Over 14)	..	2,600 calories
Adult female (Over 14)	..	2,080 ,,
Child (12 and 13 years)	..	2,080 ,,
Child (10 and 11 years)	..	1,820 ,,
Child (8 and 9 years)	..	1,560 ,,
Child (6 and 7 years)	..	1,300 ,,
Child (4 and 5 years)	..	1,040 ,,
Child (2 and 3 years)	..	780 ,,
Child (To 2 years) ..	..	520 ,,

These standards must, of course, vary in relation to physique, occupation and habits of

[1] Aykroyd, W. R., *Nutritive Value of Indian Foods and the Planning of Satisfactory Diet*, Health Bulletin No. 23, (Nutrition Research Laboratories, Coonoor, India), 1937.

life of the individuals; and we should remember that the influence of climate on dietary requirements is no less an important factor. It is held, for example, that the dietary to which Europeans are accustomed should be greatly modified in the tropics.[1]

Now, the theory of calories tells us how much of the different kinds of food is required for people of different ages who are doing different kinds of work. But it tells us nothing at all about how much of the three essential nutrients, namely, proteins, carbohydrates and fats, is needed to maintain the body in a healthy condition; that is, it gives no indication of the proportion of the total number of calories required which should be drawn from each of the three nutrients. As far as the theory of calories is concerned, it makes no difference whatever whether we live entirely on rice or entirely on milk, so long as the total number of calories is adequate.

[1] Some of the early British traders in India gave expression to this view in a letter from Surat to the East India Company as follows:

'......therefore, wee for our part doe hold that in things indifferent it is safest for an Englishman to indianize, and so conforming himself in some measure to the diet of the country....'

We have already seen, however, that it is in fact very important indeed that our diet should be balanced, that is, it should contain all the three main classes of food-stuffs in the right proportions. What are these proportions, and how can they be measured? This question is far more difficult to answer precisely than the question of how much energy is needed. In the case of protein, it is only within the last year or two that sufficient evidence has come to light to make any very definite or accurate recommendations about the best (or *optimum*) intake. In the case of carbohydrates and fats, we are still in the position of having to base our recommendations rather upon the amount that healthy people, whose choice is unrestricted, do in fact eat than on more precise physiological data about the actual needs of the body.

Let us take proteins first. We have seen that while protein can be used to supply energy, its main and specific function in the body is to build and maintain tissue. Now the body is continually using up and wearing out its tissues, and it constantly needs fresh materials out of which to rebuild them. A regular supply of protein is therefore essential. It is clear that if we knew how fast the tissues

were used up, we should be able to calculate how much new material was required. As a matter of fact it is possible to measure fairly accurately the daily wastage of tissue, for when tissues wear out, their proteins break down and the nitrogen of these proteins is excreted in the urine, the amount of which can be measured. The body, then, must take in at least enough nitrogen to replace that which is daily given off. Scientists say that when the amount of nitrogen taken in is exactly equal to that given off, the body is in 'nitrogenous equilibrium'. We have already described how the different kinds of protein are made up of a large number of nitrogenous acids, called amino-acids, and how it is these, and not the proteins themselves, which the body uses. Since some amino-acids are more valuable to the body than others, it is important to know the exact composition of the proteins; for only in this way can it be determined how much of any given protein is required. We must also remember that the absorption value of proteinous foods is to a great extent dependent on methods of cooking. The ability of proteins to satisfy the nitrogenous needs of the body can be measured and is called their 'biological value', that is

to say, the proportion of protein which when digested can actually be used by the organism for the creation or maintenance of tissue. This biological value can be accurately worked out for all proteinous foods. When the biological value of any protein or combination of proteins in a diet is known, and when we know also the amount of nitrogen cast off by the body, it is a simple problem of arithmetic to determine the quantity of any food that must be eaten to make the two figures balance. This is the essential factor in determining the *optimum* proportion of protein in any diet.

We have just said that proteins differ greatly among themselves in their usefulness. Thus the biological value of the protein found in milk is very high, while that of the rice protein is low. It is found that by a small addition of certain good proteins to those which are not so good, the biological value of the whole mixture is raised very considerably. Such a mixture of proteins in the diet is known as 'supplementing', and it is obviously of great practical importance in the planning of satisfactory diets. It is generally the case that the 'good' proteins are expensive while the poorer ones tend to be relatively cheap.

Thus by skilful supplementing, an inexpensive diet poor in proteins may be greatly improved by the addition of a small quantity of good protein at very little additional expense. Let us take one example. The biological value of white flour is 52, that of meat, 69. But a mixture of the two, in proportions of two-thirds flour and one-third meat, has a biological value of 73.

It should now be clear that as far as protein is concerned the *optimum* standard of intake can be fairly accurately measured. A great change has taken place in the standards put forward by scientists as our knowledge has advanced. Thus in the early days of nutritional science, many investigators, basing themselves largely on the amount that healthy people did actually eat, suggested an intake of as much as 127 grammes of protein a day. The latest report of the Technical Commission of the League of Nations, however, suggests a standard of not much over half this amount. It says that for an adult, the protein intake should be approximately one gramme per kilogram of body-weight. This means that an average man weighing 150 lb would need only 68 grammes of protein a day. Even this standard is now considered somewhat

high, in the light of the recent investigations into biological values, of which we have just given an account.

One further point before we leave the subject of proteins. A growing child requires more protein than an adult. Since the function of protein is to build tissue, it is clear that more will be required when the body is growing than when it has attained its full development and needs only to maintain its full-grown tissues. At least two-thirds of the proteins in the diet of children should be those that are obtained in milk and milk-products.

We now come to the question of carbohydrates and fats. Unfortunately there is little precise information about the *optimum* intake of these important dietary constituents. It will be remembered that carbohydrates form the most important, economical and readily available source of energy, and fats also furnish energy and contribute to the maintenance of body warmth. It is probable that they also serve other purposes in the body, but very little is yet known about these specific functions. Since this is the case, the proportions in which they are used in the diet are to a certain extent a matter of convenience and individual taste, always providing that

the total amount supplies sufficient calories. It should be borne in mind that fat supplies about twice as many calories per gramme as carbohydrates. It is thus a very concentrated form of fuel, and can be used if it is desired to reduce the bulk of the diet or to make it more appetizing; for if all the calories are supplied by carbohydrates it will be found that the diet is very bulky and unappetizing. But the amount of fat-intake is limited by the fact that it is not easily digested. In general, it is advisable to preserve a just balance between the two constituents, and the recommendation of 100 grammes of fat and 400 grammes of carbohydrates, put forward by the Advisory Committee to the British Ministry of Health, has gained a certain favour and probably represents the best estimate possible in our present state of knowledge.

If our information about the *optimum* intake of carbohydrates and fats is inadequate, that concerning the intake of vitamins and mineral elements is even more so. Various standards have been suggested both for vitamins and for minerals, but they have not yet been sufficiently tested to gain general acceptance and to

be of much practical value.[1] The remarks of Burnet and Aykroyd on this subject are probably the most sensible that can at present be made: 'Satisfactory quantitative data being absent, we must emphasize the necessity for a very abundant supply of the known vitamins. There is no evidence that any diet composed of natural food-stuffs contains vitamins in such excess as to produce harmful effects, and, on the other hand, we know that vitamin deficiency produces the most serious consequences.'

These are, then, some of the basic principles on which dietary standards should be based. If we are asked what would be the essential features of a balanced diet, we can state as follows:

A balanced diet should (*a*) yield an adequate amount of energy necessary for the functions of the body. In other words, its calorific value should be sufficient to meet the energy

[1] A rough estimate of the mineral requirement per day of a normal adult has been worked out as follows:—

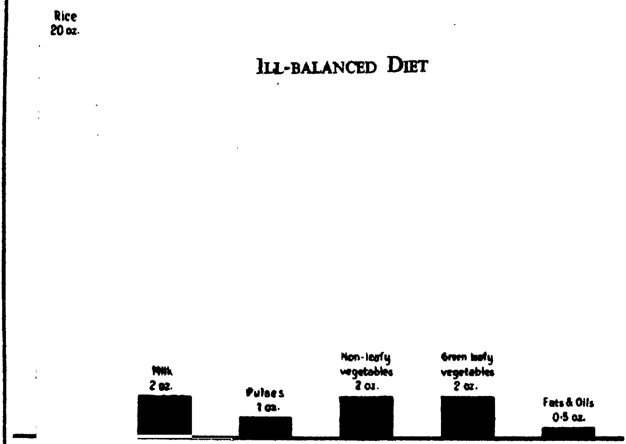
Calcium	·7 to 1·0 gramme
Phosphorus	·7 to 1·0 ,,
Iron	·006 ,,
Iodine	·00001 ,,
Sodium	·8 ,,

requirements of the individual; (*b*) consist of proteins which have high biological value, and should also contain a reasonable amount of fat; (*c*) furnish sufficient inorganic constituents, especially calcium; (*d*) be sufficiently varied so as to ensure a supply of vitamins; and (*e*) its bulk should ensure a supply of a quantity of 'roughage'. One further point to complete the description is that a balanced diet should maintain the acid-base equilibrium of the body.

A *varied* diet is therefore satisfactory because it is most likely to supply sufficient energy-bearing and protective foods. A monotonous and one-sided diet offers no protection against dietary deficiency.

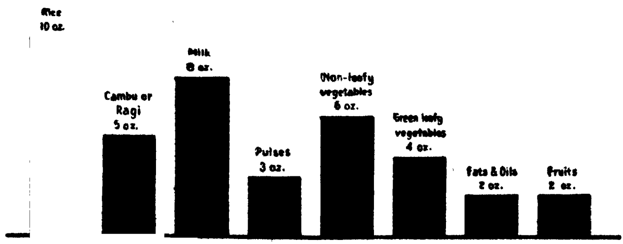
But it is not enough that our diet should be adequate just to meet body requirements; it is an *optimum* diet, we must remember, which ensures positive health and increases the resistance of the body to disease. The problem of providing an *optimum* diet to the great bulk of our population living under the stress of poverty is extremely complicated. Dietary customs and prejudices have an unfortunate effect on nutrition because they stand in the way of adjusting our food requirements to changing conditions of life

Ill-balanced Diet



2600 calories corresponding to average intake per day.

Well-balanced Diet



2600 calories corresponding to average adult intake per day.

and labour. The science of nutrition has introduced new ideas about food in relation to health and disease. We should therefore acquire such food habits as would enable us to adopt these ideas in practice. For without health we cannot be fit to play our rôle in the great adventure of life.

Chapter VIII

HOW CAN WE IMPROVE OUR DIET?

We shall now attempt to draw some practical conclusions from what we have so far discussed. There is a saying: 'Tell me what you eat and I will tell you what you are.' It means that not only is good health directly dependent upon the kind and amount of food we consume, but food exerts a profound influence upon our whole outlook on life. In other words, our physical and mental efficiency depends very largely upon what we have described as a balanced diet. 'Liberal consumption of all the essential constituents of a normal diet,' writes a distinguished American nutritionist, 'prompt digestion and absorption, and prompt evacuation of the undigested residue from the intestine before extensive absorption of products of bacterial decomposition of protein can take place, are the optimum conditions for the maintenance of vigour and characteristics of youth.' With the advancement of the science of nutrition, it is being made clear that the elimination of disease is not merely dependent upon the use of

medicine, but upon a proper adjustment of diet and habits. Should the dead weight of customs and prejudices stand in the way of making such adjustment, they have to be overcome by conscious efforts. Neither appetite nor racial habits can be depended upon to guide the choice of food.

We should always guard ourselves against the tendency to consume more food than is necessary to satisfy hunger. A famous physician, Galen, justly observed that 'more are killed by gluttony than by the sword'. Excessive eating is prejudicial to health and it is injurious to the mind; consequently it should be avoided. The quality of food intake is more important than its quantity, although both are essential in maintaining health. We should not indulge in highly spiced foods. While condiments contain appetizing ingredients which may be helpful in digestion under our climatic conditions, their excessive use is positively unhealthy because they irritate the mucous membrane of the alimentary tract. Plain and simple food need not be dull if a *mixed* diet is planned: one which is likely to balance the nutrients more easily than a monotonous diet consisting of cereals, legumes and insufficient vegetables.

A common error in our diet is an excessive consumption of carbohydrates and this should be corrected.

Considering the standard of nutrition in India, McCarrison suggests a mixed diet as follows: 'A diet composed of any whole cereal grain or mixture of cereal grains, milk, the products of milk—butter, curds and buttermilk—legumes, green leafy vegetables, root vegetables, fruit and water, with meat occasionally.'

While in the economic and social circumstances of India, such a standard cannot be widely adopted, we can certainly improve our existing dietary habits by a wise selection of the available foods. Every effort should be made to so utilize incomes, no matter how meagre, that this standard is reached. The attainment of positive health is a duty which we owe to ourselves and to our country. Good health is part of the wealth of a nation.

In the first place it is better to use mixed cereals. The low protein content of rice can be made up by the consumption of wheat or millet, thereby increasing the nutritive value of the diet. Those who are in the habit of eating rice should use unmilled or home-pounded rice. Whenever possible, cereal

grains should be steamed. *Atta* mixed with milk and *gur* would make a wholesome porridge.

We should avoid as far as possible all forms of processed foods, such as refined sugar, milled cereal grains, preserved food-stuffs and specific products advertised as being the most expedient remedies for dietary deficiencies. Food-stuffs produced by machines and commercial processes are impoverished products, and their regular consumption in any great quantity leads to deficiencies which are injurious to health. The excessive use of refined sugar, cane or beet, is a serious dietetic blunder because they contain none of the mineral elements and vitamins of the sugar-cane and the beetroot. *Gur*, molasses and honey should take the place of refined sugar.

Secondly, our diet must include a proportion of good fats. Stress is laid upon the word proportion because there must be a balance between fats and carbohydrates so that the process of combustion may be normal. An excess of fat is undesirable because it is incompletely oxidized in the body. Most diets in India are, however, low in fats. Money spent on butter and *ghee* is an insurance

against many ailments from which people in India suffer. Among the sources of vegetable fats, coconuts, groundnuts, cashewnuts and soya beans are the food-stuffs which would make up the deficiency of fat in our diet, but they cannot replace butter and *ghee.*

Thirdly, it is important that our diet should contain a generous supply of vegetables and fruits. We have seen why they are so essential for the normal development of the body and for all its functions. A lack of these food-stuffs undermines health and exposes one to infectious diseases, and that is why they are classed as 'protective' foods. Properly cooked vegetables, especially green leafy sorts, the use of more legumes—steamed, boiled, sprouted—and the inclusion of dried fruits, almonds and nuts in our diet would ensure the supply of essential inorganic substances and vitamins. Vegetables must be used intelligently. It is important that we cook them in their own juices or with very little water. It is good to drink the juices in which vegetables have been cooked. It is advisable to eat many fruits and vegetables (such as apples, cucumbers, carrots, potatoes, radishes) without peeling them because there are certain important and nutritious inorganic

substances in the peelings or immediately underneath them.

Most people in India do not eat a sufficient quantity of fresh fruits and vegetables, but if it were realized that their consumption would minimize to a great extent the effects of dietary deficiency, more money would then be spent on these food-stuffs rather than on amusements and unnecessary articles of luxury. We should cultivate the habit of eating dried fruits like dates, figs, prunes, raisins, apricots, etc. These are better sweets than the confectionery which contains refined sugar. The practice of eating uncooked food consisting of fresh and dried fruits at least once a day every week should be encouraged.

In the absence of fresh vegetables, certain legumes, such as beans, gram, and peas, may be sprouted and eaten raw or cooked. Seeds are soaked in water for twenty-four hours and then kept moist for another forty-eight hours when the sprouts will appear. Sprouted legumes are important as a source of vitamin C.

Fourthly, milk, meat, eggs and fish, and foods of animal origin, are sources of good proteins and should constitute, as already shown, a part of a mixed diet. *Provided* a

diet includes a liberal supply of milk and milk-products, pulse, green leafy vegetables, nuts and fresh fruits, meat, eggs and fish are not essential for the maintenance of health. In considering the case for and against purely vegetarian diets, we should bear in mind that our usual dietaries are too rich in carbohydrates and poor in proteins of biological value, mineral elements and vitamins, and that a diet consisting of cereals and legumes cannot supply the best nutrition. Where milk and milk-products are not available, or beyond the means of the consumer, he would be well advised to include eggs in his diet. Among the non-vegetarians, the greater use of fish should be encouraged. Rich proteinous foods are not suitable to persons living under tropical conditions and therefore meat may be excluded from dietaries in the Tropics.

Every possible means should be adopted for increasing the consumption of milk and milk-products. This is a particularly important consideration for those who are averse to eating fish or even eggs. Milk is both an economical and protective food and is especially valuable as a source of calcium and phosphorus in the diet. Even a partial increase in its supply would greatly

reinforce the faulty and ill-balanced diet of the majority of the people of India.

A correct estimation of a minimum quantity of milk required depends mainly upon the age, occupation and nutritional state of each individual. According to existing dietary standards the quantity of milk required for the maintenance of normal health varies from fifteen to thirty ounces per head per day. It is estimated that the standard requirement in India should be fifteen ounces per day, although in a suggested well-balanced diet, W. R. Aykroyd allows only eight ounces as against two ounces in an ill-balanced diet. We should, however, note that this low estimate of eight ounces is recommended because under the existing circumstances of milk production and milk distribution, it is not possible to provide the standard requirement. At any rate in the extended use of milk and milk-products lies the hope of any substantial improvement in our dietaries. The habit of drinking sour milk, butter milk, skimmed milk, whey and fruit sherbets of all kinds should be encouraged. It is unfortunate that the consumption of tea is increasing in India. Tea is not a food. Its food value is determined by other constituents, such as

milk, sugar, or lemon, that are added. Owing to the presence of an astringent substance, tannin, tea may even be harmful to the digestive tract.

Lastly, we should remember that nutrition is not the same thing as diet and that our nutritional condition depends not only on what food we eat but also on keeping the body fit. Therefore proper exercise of the body, the practice of deep breathing, sufficient rest and sleep, a cheerful mind—all these are helpful in improving the state of nutrition. A close relationship exists between physical exercise and diet. While physical exercise is an important factor in building up a healthy body, a badly nourished body cannot derive much profit by it. Therefore proper nutrition and reasonable exercise must go together in the making of a healthy body.

Then there are certain dietary habits which we should cultivate in order to derive most benefit from the food consumed. Food must not be eaten in a hurry and each morsel must be chewed as thoroughly as possible. Remember that enzyme called ptyalin has to change starch into sugar in your mouth.

The practice of not drinking much water with meals is sound, but it is necessary

to drink plenty of water, sherbet and other similar beverages in the course of a day.

You must guard yourself against faulty elimination of waste products. Imperfect action of the bowels or constipation is very injurious to health but it can be easily corrected if you are wise in choosing the right food. Figs, dates, prunes, mangoes, apples, cucumbers, cooked vegetables with plenty of roughage, and cereals that have not been milled or refined are good laxative foods.

When we eat a little too much, or too much useless food, both stomach and liver are likely to be overworked. One of the real causes of that 'tired feeling' is the overworked digestive organs. It is therefore beneficial to give them a rest and not to eat any solid food for a day or so. During this time we should take plenty of fruit juices or some kind of vegetable broth. Temporary fasting as a means of treatment of diseases is an ancient practice and it is indeed a sensible one.

We have now come to the end of our study of certain fundamental principles of nutrition. They should teach us to realize that the sole purpose of eating is not just satisfying our hunger and appetite, but to keep the body in perfect health. We have seen that the inter-

related processes which build and regulate the great wheel of life are dependent upon proper and adequate nourishment. The attainment of positive health which is determined by nourishment is something more than freedom from disease. It is characterized by harmony and the well-being of the entire Self, that is, of the body, the mind and the Spirit. That is why the sages regarded eating as a kind of religious act. If we fail to achieve this harmony, we cannot offer the body, in the words of our Poet, as 'a lamp in the Shrine of our Creator'.

APPENDIX A

NUTRITION CHART 1

Sources of carbohydrates, proteins and fat

Substances	Specific function in body	Some common natural sources	
		Vegetable products	Animal products
Carbohydrates (contain carbon, hydrogen and oxygen.)	Chief source of energy (calories).	Cereals, tapioca, potatoes, legumes, cashew nuts, dried fruits, sugar, honey, *gur*, jaggery.	..
Fats (composed of carbon, hydrogen and oxygen.)	Furnish energy (calories).	Oilseeds of all kinds, olive oil, coconut, nuts, especially groundnuts, (widely used for extracting edible oil). Vegetable *ghee* or margarines are prepared from vegetable oils.	Whole milk, cream, butter, meat fats of all kinds.
Proteins	Build and maintain body tissue; also furnish energy (calories).	Nuts of all kinds, legumes, whole cereals.	Milk, casein, fish, eggs, meat of all kinds.

NUTRITION CHART 2

Sources of certain mineral constituents in foods

Substances	Specific function in body	Some common natural sources	
		Vegetable products	Animal products
Calcium	Bone and tooth formation (see under phosphorus) and muscle activity. Essential for blood coagulation.	Green leafy vegetables, amaranth leaves and stem; dry legumes, wheat bran, beet, carrots, cabbage, cauliflower, okra, fruits, dried prunes, figs, almonds, walnuts.	Whole milk, buttermilk, whey, cheese, egg-yolk.
Phosphorus	An essential constituent of every living body-cell; as calcium phosphate is most important constituent of bones and teeth.	Whole cereal products, rice-polishings, lentils, peas, soya beans, potatoes, nuts.	Whole milk, buttermilk, whey, cheese, egg-yolk, fish, lean meat.
Iron	An essential constituent of the oxygen-carrying pigment of the blood (haemoglobin).	Green vegetables, whole wheat, dried beans and peas, dried fruits, nuts.	Red meat, liver, egg-yolk, shrimps.

NUTRITION CHART 2—(*contd*)

Sources of certain mineral constituents in foods

SUBSTANCES	SPECIFIC FUNCTION IN BODY	SOME COMMON NATURAL SOURCES	
		Vegetable products	Animal products
Iodine	Essential for functioning of the thyroid gland.	Sea-weeds, leafy vegetables, watercress, vegetables grown in regions where soil and water contain a fair amount of iodine.	Salt water fish, shell fish.

NUTRITION CHART 3

Sources of vitamins

FACTOR	CHIEF CONSEQUENCES OF THE DEFICIENCY IN THE DIET	SOME COMMON NATURAL SOURCES	
		Vegetable products	Animal products
Vitamin A (fat-soluble; resists heat, closely related to pigment carotene.)	Retards growth and development; affects epithelium tissues and also the proper functioning	Green and yellow fresh vegetables, spinach, watercress, green peppers, carrots, sweet	Fish liver oil, liver, whole milk, butter cream, egg-yolk.

Vitamin A—(*contd*)	of the visual purple of the retina. Eye disease, skin troubles, toadskin and sore-mouth, gastric ulcer.	potatoes, yellow squash, tomatoes, green peas, green and ripe olives, papaya, mangoes, apricot, yellow peach, banana, musk melon, pine-apple.	
Vitamin B_1 (water-soluble; resists ordinary cooking but is inactivated if subjected to great heat in alkali media.)	Affects normal functioning of nervous system and also of digestive tract. Beriberi, digestive troubles, loss of appetite.	Brewers' yeast, wheat germ, whole cereal grains, bran, cabbage, spinach, legumes, potatoes, carrots, onions, tomatoes, fruits in general, lady's fingers, peanuts, almonds, dates.	Egg-yolk, liver and other edible organs, fish roe
Vitamin B_2 (water-soluble; more stable than B_1.)	Affects skin, digestive tracts. Pellagra, alimentary disorders.	Yeast, wheat germ, green leaves, tops of beet, radish, carrot, water-cress, cabbage, legumes.	Lean meat, liver, liver extract, eggs, whole milk, fresh, skimmed milk, buttermilk, cheese.
Vitamin C (water-soluble; easily destroyed.)	Affects blood vessels; capillary haemorrhages make their appearance. Scurvy, bleeding gums, painful joints.	Citrous fruits (all kinds), pine-apple, watermelon, musk melon, apples, sprouted legumes, cabbage, paprika (large pepper), watercress, cucumbers, potatoes, radish, tomatoes, rhubarb.	..

NUTRITION CHART 3—(*contd*)

Sources of vitamins

Factor	Chief consequences of the deficiency in the diet	Some common natural sources	
		Vegetable products	Animal products
Vitamin D (fat-soluble; more stable than vitamin A; unaffected by cooking. Human skin contains a substance which may be changed into vitamin D by sunlight.)	Retards the process of regulating bone-formation, develops rickets, absorption of calcium and phosphorus reduced, hence faulty development of teeth and bones.	..	Fish liver oil, egg-yolk, butter, milk.
Vitamin E (fat-soluble; stable, not readily destroyed by heat.)	Affects reproduction in experimental animals. Sterility in the male. Young embryo do not grow normally in female.	Wheat germ oil, wheat germ, lettuce, watercress, peas, vegetable fats.	Liver, egg-yolk, milk.

APPENDIX B

	Protein		Fat		Total carbo-hydrates		Inorganic constituents	
	Per-centage	Tolas per seer	Per-centage	Tolas per seer	Per-centage	Tolas per seer	Per-centage	Tolas per seer
Bajra	11·6	9·3	5·0	4·0	67·1	53·7	2·7	2·2
Cholam	10·4	8·3	1·9	1·5	74·0	59·2	1·8	1·4
Ragi	7·1	5·7	1·3	1·0	76·3	61·0	2·2	1·8
Rice, raw, milled ..	6·9	5·5	0·4	0·3	79·2	63·4	0·5	0·4
Wheat, whole	11·8	9·4	1·5	1·2	71·2	57·0	1·5	1·2
Bengal gram	17·1	13·7	5·3	4·2	61·2	49·0	2·7	2·2
Black gram	24·0	19·2	1·4	1·1	60·3	48·2	3·4	2·7
Green gram	24·0	19·2	1·3	1·0	56·6	45·3	3·6	2·9
Red gram	22·3	17·8	1·7	1·4	57·2	45·8	3·6	2·9
Soya bean	43·2	34·6	19·5	15·6	20·9	16·7	4·6	3·7
Amaranth leaves ..	4·9	3·9	0·5	0·4	5·7	4·6	3·1	2·5
Drumstick leaves ..	6·7	5·4	1·7	1·4	13·4	10·7	2·3	1·8
Colocasia	3·0	2·4	0·1	0·1	22·1	17·7	1·7	1·4
Potato, sweet	1·2	1·0	0·3	0·2	31·0	24·8	1·0	0·8
Radish	0·7	0·6	0·1	0·1	4·2	3·4	0·6	0·5
Brinjal	1·3	1·0	0·3	0·2	6·4	5·1	0·5	0·4
Bitter gourd	1·6	1·3	0·2	0·2	4·2	3·4	0·8	0·6
Drumstick	2·5	2·0	0·1	0·1	3·7	3·0	2·0	1·6
Lady's fingers	2·2	1·8	0·2	0·2	7·7	6·2	0·7	0·6
Plantain, raw	1·4	1·1	0·2	0·2	14·7	11·8	0·5	0·4
Groundnut	26·7	21·4	40·1	32·1	20·3	16·2	1·9	1·5
Mango, ripe	0·6	0·5	0·1	0·1	11·8	9·4	0·3	0·2
Mutton (muscle) ..	18·5	14·8	13·3	10·6	..	..	1·3	1·0
Milk, cow's	3·3	2·6	3·6	2·9	4·8	3·8	0·7	0·6

APPENDIX C

Experiments on Nutrition

Some of the characteristics of nutritive substances derived from our common food-stuffs may well be demonstrated by a series of simple experiments. The list of materials required in the experiments suggested below is as follows:

Iodine solution
Fehling's solution
Diluted hydrochloric acid
5% copper sulphate solution
Glucose
Chloroform
A few test tubes
A few beakers or glass jars
Black paper
Glass rod

A. Carbohydrates

Experiment 1

Show that iodine produces a blue colour with starch. Try the effect of iodine on rice, bread, etc. Put a piece of rice in water in a test tube and add a few drops of iodine; the blue colour will appear. Boil the water and the blue colour disappears but reappears on cooling. These changes are characteristic of the reaction between iodine and starch and make it easy to identify starch in food.

Experiment 2

Test starch and glucose solutions by boiling with a little Fehling's solution. Starch has no effect, but

glucose rapidly produces a red coloured precipitate[1] by a process called 'reduction'. Now test the solution obtained after boiling starch and acid. It also becomes red showing the presence of sugar.

Experiment 3

Boil some starch solution with dilute acid for five minutes, cool, and show that no colour is given with iodine. The starch is split up into sugar by the acid, and the sugars do not give the colour with iodine.

Note the difference between the changes in this experiment and those in Experiment 1. In Experiment 1 the starch was not split up, but at the boiling point it does not give a blue colour with iodine. In this experiment, however, the starch is changed into sugars which do not give a colour with iodine at any temperature.

Experiment 4

Add a few cc. of saliva to a starch solution and warm at about body temperature (37°C., 98°F.) for five minutes. Test with iodine and Fehling's solution. The starch has been digested by ptyalin, the enzyme of the saliva, to form maltose, a sugar which reduces Fehling's solution.

Experiment 5

Chew a mouthful of some form of starch for two minutes and notice that it becomes slightly sweet. This is due to the sugar (maltose) produced by the action of the ptyalin on the starch.

[1] When an insoluble solid is formed during a chemical reaction it is called a 'precipitate'.

Experiment 6

To some starch solution add a few drops of saliva that has been boiled for a few minutes and show that the enzyme will no longer work. Enzymes are destroyed by boiling.

Experiment 7

In this experiment we will find out the source of starch. Cover up one leaf of a plant with black paper for several days. Boil the leaf with chloroform to extract the green colouring matter (chlorophyll) and to kill the cells. Immerse the leaf in iodine solution and notice that no blue colour develops. Repeat with an ordinary leaf and observe the dark colour formed.

This proves that sunlight is required by the plant to make starch. The chlorophyll of the plant is able to use carbon dioxide from the air and with the energy of sunlight combines it with water to form sugar and starch. This process is called 'photosynthesis' from the Greek words photos (light) and synthesis (placing together). If the source of energy is cut off, as in this experiment, then starch cannot be made.

Experiment 8

By applying Fehling's test, find out whether sugar is formed in green leaves.

B. Proteins

Experiment 9

Extract 3-4 gms. of finely chopped meat with 10 cc. warm water or dissolve a little raw white of egg in water. Boil part of the solution and notice the formation of a precipitate. This is due to a change in the protein

molecule called 'coagulation', which occurs when certain types of proteins are heated.

Experiment 10

Add 1 cc. of strong alkali to 1 cc. of protein solution and a few drops of 5% copper sulphate solution. Notice a violet colour which is always formed with proteins. This test is called the 'biuret reaction' and is given by the 'peptide' link which connects the amino-acids of the protein. It is important to add dilute copper sulphate, otherwise a deep blue, due to copper hydroxide, and not a violet colour is produced.

Experiment 11

Boil some protein solution with acid for about half an hour (the acid may have to be renewed occasionally). Notice the gradual disappearance of the coagulated protein as it is split up into simpler compounds by the acid. Try the biuret test after the boiling. It will give either a pink colour instead of violet or it will be negative and only the blue of copper hydroxide will be visible. If a pink colour is obtained it shows that the protein has been broken down to smaller compounds containing relatively few amino-acids and therefore few peptide links. If only a blue colour results then the protein has been broken down completely to amino-acids and there are no links left.

Try the biuret test on saliva. It is faintly positive because saliva contains protein. The enzyme ptyalin is a protein and the mucus of saliva is also a protein.

C. FATS

Experiment 12

Crush a number of oil-bearing seeds and they leave a stain on paper.

Experiment 13

Put a few drops of oil (mustard, linseed, coconut, etc.) or a small piece of butter in water and stir. The oil and water do not mix, and soon separate.

Experiment 14

Repeat the above experiment with a solution of chloroform, and notice that they (oil and chloroform) mix completely. Chloroform, ether, benzene, alcohol are called fat solvents because they dissolve fats, and will remove them from a mixture of substances.

Experiment 15

Shake some milk or any fat containing food with a few cc. of chloroform and allow the chloroform to settle into a layer below the milk. Pour off the milk and allow the chloroform to evaporate. It will leave a residue of oily droplets showing that fat was present in the milk and was extracted by the chloroform.

It will be found that the fat from most fatty foods may be removed by this method.

GLOSSARY

Abdomen—The lower cavity of the body containing the digestive organs (liver, stomach, intestines, etc.) the excretory organs (kidney and bladder) and certain others. It is divided from the upper cavity (or thorax) by the diaphragm.

Acid-base equilibrium—In order to enjoy normal health the body must be kept slightly alkaline. This is only possible if the food constituents which form acids balance with those which form bases (alkali). The body is able to preserve the right strength of alkali when small excesses of either acid or alkali producing substances are taken in, by altering the amount of acid excreted in the urine and the amount of carbon dioxide (acid) excreted via the lungs. But if large excesses of, for example, fat which is acid-producing, are taken, then illness may follow because the tissues become too acid. Rheumatism, gout, and kidney troubles are largely due to an excess of acid-forming foods.

Adulteration—(L. *adulterare*, corrupt). The mixing of some inferior substance with food or other articles is adulteration; e.g., milk is often adulterated with water; or *ghee* with animal or vegetable fats.

Alimentary Tract or Canal—(L. *alimentum*, nourishment). The muscular tube through which food passes while being digested and absorbed. It consists of the following main parts: oesophagus (or gullet), stomach, small intestine (about 23 feet long and much coiled) and large intestine (colon).

Amino-acids—Nitrogenous substances out of which proteins are built up.

Amoeba—(Gr. *amoibe*, change). The simplest animal known, consisting of only a single cell big enough to be visible to the naked eye. Its nucleus is surrounded by protoplasm which is enclosed in an elastic coat whose shape is always changing.

Anabolism—(Gr. *anaballein*, to build up). The constructive phase of metabolism; that is, the process of building new complex substances from the simple com-

pounds absorbed from the alimentary canal.

Anatomy—The study of the structure of the bodies of living things. The word is derived from the Greek *temno*, meaning cut, since anatomy is studied by cutting or dissecting.

Assumption—The process by which absorbed food materials are made into new tissue.

Beriberi—A disease marked by inflammation of nerves caused by lack of vitamin B.

Bile—A liquid that comes from the liver: greenish in colour, bitter in taste, and alkaline in reaction. It assists digestion in various ways although it has no power of digesting by itself.

Caecum—(L. *caecum*, blind). A branch of the alimentary canal leading off at the junction of the small and large intestines. It is closed at the end: hence the name.

Calorie—The quantity of heat required to raise 2·2 pounds (1 litre) of water 1° centigrade.

Capillaries—(L. *capilla*, hair.) The small branches of blood vessels winding around the tiny cells, supplying fuel, oxygen and

other substances from the blood as they are needed. They also collect waste products that the cells do not need.

Carbohydrates—A group of organic food substances which combine with oxygen to yield energy. Carbohydrates are composed of carbon atoms associated with hydrogen and oxygen in the same ratio as that in which they combine in water; that is, two atoms of hydrogen to one of oxygen. Hence the name carbohydrates, meaning carbon with water.

Catabolism—(Gr. *kata*, down; *ballein*, to throw). The destructive phase of metabolism; that is, the process, which is always going on in the body, of breaking down complex substances into simpler ones prior to oxidation or excretion.

Catalyst—A substance which accelerates a chemical reaction without taking part in it. Enzymes are catalysts.

Cell—(L. *cella*, a small room). When examined through a microscope the bodies of living things are found to be divided up into tiny sections called cells. They are divided from one another by membranes (the cell walls) and contain proto-

plasm, a part of which (the nucleus) is different from the rest and seems to control the life of the cell. In other words, the cell is the unit of living structure and function.

Cellulose—A carbohydrate substance which forms the walls of plant cells.

Chlorophyll—Green pigment, present in plants and essential for their nutrition.

Chyme—The semi-liquid food in the small intestine.

Combustion—The process of burning, consisting of the chemical combination of a substance with oxygen. Combustion causes the liberation of energy usually in the form of heat.

Dehydration—(Gr. *hydra*, water). The removal of water from any material.

Diastase—A starch-splitting enzyme.

Digestion—The process of breaking up the complex compounds in food into small soluble substances which can be absorbed through the walls of the alimentary canal.

Duct—(L. *ductus*, leading). A small tube leading from a gland through which the

gland's secretion is conducted to the part of the body where it is required. For example, the pancreatic duct leads from the pancreas, where the pancreatic juice is formed, to the small intestine where it performs its digestive work.

Duodenum—(L. *duodeni*, twelve). The first part of the small intestine which joins on to the stomach. So called because it is about twelve inches long.

Emulsification—Some liquids (e.g., oil and water) do not mix or dissolve in one another but it is usually possible to make them behave as though they mixed and to avoid their separation, by the process of emulsification. This consists of breaking up one liquid (in the body it is the fatty materials which are broken up) into very small droplets which can be scattered throughout the other liquid causing a mixing almost as thorough as if they were actually soluble.

Endocrine glands—A gland which produces a substance, secreted directly into the blood by which it is carried to all parts of the body. The products of endocrine glands

(hormones) may, therefore, affect many parts of the body at once.

Energy—(Gr. *en*, in, *ergon*, work). The capacity of being able to work. A moving object can move other objects if it collides with them; that is, it does work and it is because a moving object has the power to do this work that we say that motion is a form of energy.

Energy exchange—Energy can exist in several forms; e.g., heat, motion and electricity. These forms can be changed from one to the other. A boiler fire changes water into steam which can drive an engine. Thus heat is being changed into motion which is an example of energy exchange.

When a substance is built up from simpler substances, energy is required and this energy is set free again if the substance is broken down. In the body food substances are burned and the energy used when they were built up is set free. Some of this is used for moving the body (doing the external work) and some of it is used as heat to keep the body temperature at its proper level of 37° C. or 98° F.

Environment—The surroundings or circumstances in which a living thing is placed; particularly the temperature, amount of light, moisture, quality and quantity of food.

Enzymes—Organic catalysts; that is, complex organic substances which occur in living tissues and which have the property of speeding up chemical changes essential for life.

Excretion—(L. *ex*, out, *cret*, sift). The process by which the body removes unwanted or harmful substances.

Fats—A group of organic food substances which combine with oxygen and furnish the body with energy.

Fatty acids—A group of substances formed in the digestion of fats.

Faeces—Waste materials rejected by the body from the alimentary canal.

Gastric juice—(Gr. *gaster*, stomach). The strongly acid liquid produced by the glands of the stomach containing enzymes which bring about the digestion which takes place in the stomach.

Gland—An organ which produces a substance or mixture of substances for the use of the body. For example, the stomach wall contains many glands which produce the gastric juice; the thyroid is a ductless gland and sends its product direct into the blood by which it is conveyed to all the tissues of the body.

Glycerol—A substance formed by the digestion of fats.

Glycogen—(Gr. *glycos*, sweet, *genan*, to produce). A whitish solid substance which dissolves in water forming a cloudy solution. On boiling with acid it is changed to glucose (a simple sugar).

Animals store glycogen in the liver and to a less extent in the muscle cells. It is built up from the glucose of the foodstuffs. The stored glycogen is reconverted to glucose by enzymes when required.

Haemoglobin—(Gr. *haima*, blood, *globos*, ball). The red colouring matter of blood which has the property of combining with or liberating oxygen depending on the conditions. Owing to this property it is the

means by which oxygen is carried from the lungs to the tissues.

It contains an iron compound (*haem*) combined with a protein.

Hormones—The product of an endocrine gland.

Immunity—Condition of being able to resist the attacks of disease.

Infection—An invasion of the body tissues by harmful organisms.

Ingestion—The taking in of food.

Inorganic—Generally speaking, substances not containing carbon.

Lipase—Any fat-splitting enzyme.

Lymph—(L. *lympha*, water). The colourless slightly alkaline liquid which passes out from the capillaries and surrounds the tissues. It conveys food material from the blood to the cells and carries waste products from the cells back to the blood. The channels into which it collects before returning to the blood are called lymphatics.

Mastication—The process of chewing, or breaking up of food by the teeth, tongue and movements of the jaws.

Metabolism—(Gr. *metabole*, change). The *sum* total of all physical and chemical changes which food materials undergo after entering the blood stream. (*See* anabolism, catabolism).

Micro-organisms—(Gr. *mikros*, small). Very minute living things, e.g., bacteria, which are only visible with a powerful microscope.

Nucleus—(L. *nucleus*, kernel). Part of the protoplasm of a cell which is different from the remainder and which is essential for the life of the cell, since the cell dies when it is removed.

Oesophagus (or gullet)—(Gr. *oisem*, to carry, *phagema*, food). Tube which carries food from the throat to the stomach.

Organ—A part of the body that has a special function or a number of functions and has, to a certain extent, an independent structure.

Organic—A substance containing carbon.

Organism—Any living thing, whether plant, animal or bacteria.

Pancreas—It is a gland which lies just behind the stomach and sends a juice, rich in

enzymes needed in digesting food, into the small intestine.

Parasite—(Gr. *para*, beside, *sitos*, food). An organism that lives at the expense of and usually inside another organism, e.g., the tape worm which lives in the alimentary tract of men and animals and obtains its nourishment from the animal (its 'host').

Pellagra—A disease caused by lack of vitamin B_2.

Pepsin—An enzyme found in the stomach which reduces proteins to peptones.

Peristalsis—(Gr. *peri*, round, *stello*, send). The waves of contraction and relaxation which travel along the muscle layers of the alimentary canal and certain other organs and cause the contents to be moved.

Physiology—(Gr. *phusis*, nature, *logos*, a discourse). It means the study of the characteristic processes of life.

Protein—A group of complex chemical compounds which in conjunction with water furnish the chief contents of protoplasm.

Protoplasm—(Gr. *protos*, first, *plasma*, form). The very complex mixture of proteins

which forms the main bulk of living cells. It is a colourless, slimy, fairly transparent material.

Ptyalin—An enzyme found in saliva which reduces starch to simple compounds.

Rennin—A stomach enzyme which curdles milk.

Respiration—(L. *re*, again, *spirare*, to breathe). The process of breathing which includes two separate types: (*a*) external respiration which constitutes the movements of the chest pumping air into the lungs and removing carbon dioxide; (*b*) internal respiration which refers to the actual means by which the oxygen is used by the tissues.

Retina—Sensitive membrane in the eye upon which an image of the outside world is focussed.

Saliva—The alkaline juice produced by certain glands (the salivary glands) and passed into the mouth where it mixes with the food during mastication and makes it easier to swallow, due to a slippery substance called mucus which it contains.

Scurvy—A disease caused by lack of vitamin C.

Secretion—The process which glands carry out, consisting of the formation and expulsion of a solution or juice, required by the body.

Synthesis—The building up of a chemical compound from simpler substances.
For example, (*a*) water may be synthesized by sparking a mixture of oxygen and hydrogen, and (*b*) sucrose is synthesized when the simple sugars, glucose and fructose, combine together.

Thorax—The upper cavity of the body enclosed by the ribs which contains the heart and lungs and is divided from the abdomen by the diaphragm, a muscular partition.

Tissue—A group of cells that are alike in structure and function.

Toxin—A substance which is poisonous to the body.

Urea—When amino-acids are not required by the body, their nitrogen is split off and is converted into a substance called urea. It enters the urine and is the most

important nitrogenous substance in the urine.

Villus (pl. villi)—One of the minute finger-like structures in the wall of the small intestine into which the food substances are absorbed.

Xerophthalmia—A disease of the eyes caused by lack of vitamin A.

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